

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

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Please use either the buttons on the left or top right of the page to navigate your way around this interactive PDF

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November | December 2016

INTERNATIONAL **Fertilizer**

www.fertilizerinternational.com



Fertilizer Latino Americano, Buenos Aires
Argentina's fertilizer market
Drip irrigation review
P&K mining innovation



CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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Fertilizers: Education for Life

Intertrade Group, within its mission of developing the best agronomic and ethico-commercial practices, supports the initiatives of the "Nutrients for Life" Foundation, a global organization of educational purposes which is focused in raising public awareness on the importance of fertilizers in the production of food, promoting a sustainable agriculture to guarantee the planet's nutritional and food intake safety. The "Nutrients for Life" organization seeks to clarify the relevance of the adequate use of soil for one responsible agriculture and cattle raising activity, respecting the ecological integrity of ecosystems and achieving then, higher productivity and economic and social betterment in this sector. The influence of fertilizers in the plants nutritional cycle is directly related to the quality and the availability of the food that we consume, therefore, the "Nutrients for Life" project supports the scientific study of the benefits of fertilizers in the food quality and quantity, contributing for the clear comprehension of the vital cycle of life and its relation to human health and survival. We commend the actions of "Nutrients for Life" in trying to make society aware of the responsibility of this important fertilizer sector in supplying the increased world demand for food.



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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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Selection of Key Speakers

 Anil Chandramani, *Chief Investment Officer*
International Finance Corporation

 Grant Roberts, *Chief Agronomist*
Yara Asia Ltd

 John Hassell, *Research Manager*
Koch Industries

 Krish Shanmuga, *Global R&D Director*
Solvay

 Ravi Prasad, *President - Marketing*
Coromandel International Limited

 Teferi Belayneh, *R&D Manager*
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attend event for you to ensure you
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6 Industry news



20 El Niño hits demand



28 P&K innovation

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NUMBER 475

NOVEMBER | DECEMBER 2016

CONTENTS

9 A merger of equals?

The proposed merger of Agrium and PotashCorp looks set to create a Canadian-headquartered fertilizer giant worth more than \$25 billion. The combined company would also be a dominant force in North American fertilizer production, controlling 62% of potash capacity, 30% of phosphate capacity and 29% of nitrogen capacity, according to some estimates.

13 Fertilizer Latino Americano preview

We look ahead at Latin America's leading fertilizer conference taking place in January at the Sheraton Hotel and Convention Center, Buenos Aires, Argentina.

13 Argentina's rejuvenated fertilizer market

Argentina is the second largest agricultural producer in South America. Confidence in the country's agricultural sector is riding high following the recent introduction of sweeping policy reforms. These have prompted a strong recovery in fertilizer sales in 2016, with January-August purchases up 50% year-on-year.

17 Getting more crop per drop

Although more than 11 million hectares of land are watered by drip irrigation globally, the technology's agricultural potential is still in its infancy. The thriving commercial market for drip irrigation equipment is worth \$2.2 billion and expanding by around a fifth every year. Fertigation, the ability to efficiently manage and regulate both water and plant nutrients, is one of the factors helping drive worldwide growth.

20 'Godzilla' El Niño leaves a lasting legacy

We review the impact of the 2015/16 El Niño on global agriculture and fertilizer demand, and assess how climate change is influencing this irregular weather phenomenon. The maize harvest in South Africa, wheat production in Morocco, Malaysian palm oil output and rice growing in India were all hit by the latest El Niño event.

23 Fertilizer handling – a growing market

Moving from traditional fertilizer handling methods to the latest technology offers great operational gains and clear commercial advantages. The benefits of such as switchover can prove surprising, as Bertil Andersson, Siwertell's sales manager, explains.

PHOSPHATES AND POTASH INSIGHT

25 SOP – the second largest potash market

Sulphate of potash (SOP) fertilizer commands a premium price due to its value as a chloride-free source of potash for lucrative cash crops such as tobacco, tree nuts and citrus fruits. We examine the global demand for SOP and the prospects for new primary and secondary supply over the medium-term.

28 Phosphate and potash mining innovation

We look at state-of-the-art technology used in phosphate and potash mining, including continuous mining and haulage systems, in-pit crushing and conveying, and paste plants for tailings thickening.

REGULARS

- 4 Editorial Openness and transparency
- 5 Market Outlook
- 6 Industry News
- 8 People & Calendar
- 30 Index to advertisers

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino
Americano,
Buenos Aires

COVER FEATURE 2

Argentina's
fertilizer market

COVER FEATURE 3

Drip irrigation
review

COVER FEATURE 4

P&K mining
innovation

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Openness and transparency



Long haul overnight flights. Four words guaranteed to provoke unhappiness in a homeward-bound traveller. But flying back to London from this year's World Fertilizer Conference in San Diego in September did have one silver lining: the chance to read an innovative new report from conference organisers, The Fertilizer Institute (TFI).

TFI has thought carefully about how the fertilizer industry is viewed by the public and responded by attempting something bold and imaginative. For the past year, the Institute has painstakingly documented the performance of the US industry using a range of economic, environmental and social indicators. The upshot of this has been the publication of its first ever *State of the Industry Report*.

Having instant access to information is now the norm for citizens in the digital age. "As consumers, this is helpful as we try to make informed decisions about our purchases, eating habits, and everyday behaviours," points out Jennifer Martin, TFI's public relations director. She adds: "For an industry, it creates a climate of transparency and a demand from consumers for companies to be open about their business practices."

All industries now operate in a climate of increased scrutiny – even the fertilizer industry. Although demands for greater openness and transparency may have been resisted in the past, self-examination does have very real business benefits. Especially if it helps flag-up performance and operational shortfalls, as Chris Jahn, TFI's president, explains: "Sustainable growth requires the industry to balance economic performance with environmental and social responsibilities. Measuring and evaluating our efforts provides a way to track performance and identify areas we can target for improvement."

TFI's new report measures the US fertilizer industry's contribution to the economy, resource conservation and nutrient stewardship. It gathers all this information together in one place for the first time, and presents it attractively. The result is an accessible, fact-filled and illuminating read.

The US is the fourth-largest producer of nitrogen-based fertilizers in the world and the second-largest producer and exporter of phosphate fertilizers. In 2014, the industry's contribution to the US economy totalled more than \$139 billion. That sum captures the entire value that fertilizer production creates, both upstream and downstream – from manufacturers and

suppliers to wholesalers and retailers. All of these activities support 450,000 jobs in the US, many of which are ranked among the best in their communities, says TFI.

The US industry directly employs 80,000 people, generates outputs worth \$58 billion and pays \$13.2 billion in taxes every year. Fertilizer retailing employs 42,000 and contributes \$20 billion to this total. Manufacturing and wholesaling create a further 38,000 jobs and an additional \$38.5 billion in economic value. US fertilizer companies are also continuing to invest large sums in new capacity, equipment and technology. TFI member companies have collectively made capital investments of \$1.9 billion annually in recent years.

Materials, water and energy are essential but costly inputs to fertilizer manufacturing. That makes resource efficiency and conservation a priority during production. Encouragingly, TFI member companies recycle and re-use water around four times on average during the fertilizer production process. They also reduced their total water use per tonne of product by 13% year-on-year in 2014, and improved the capture of waste heat during production by 4%.

TFI is also fully engaged when it comes to sustainable fertilizer use. The Institute and its member companies have long championed 4R nutrient stewardship as a means of protecting the environment and increasing farm profitability. Many fertilizer producers and retailers in the US employ Certified Crop Advisers (CCA) and Certified Professional Agronomists (CPA) to roll-out 4R principles at farm-level. These professionals, by assisting in the analysis of soils and crops, help farmers make informed choices about buying and applying fertilizers. Some 2,730 fertilizer company employees now advise farmers in the US as a regular part of their jobs. Around a quarter of these staff are CCA or CPA qualified.

The above information is just a one-year snapshot of the state of the US fertilizer industry. Importantly, it provides a valuable baseline which future improvements can be measured against. TFI's openness and transparency is commendable, especially if it allows an informed dialogue to take place between the industry and those it serves. ■

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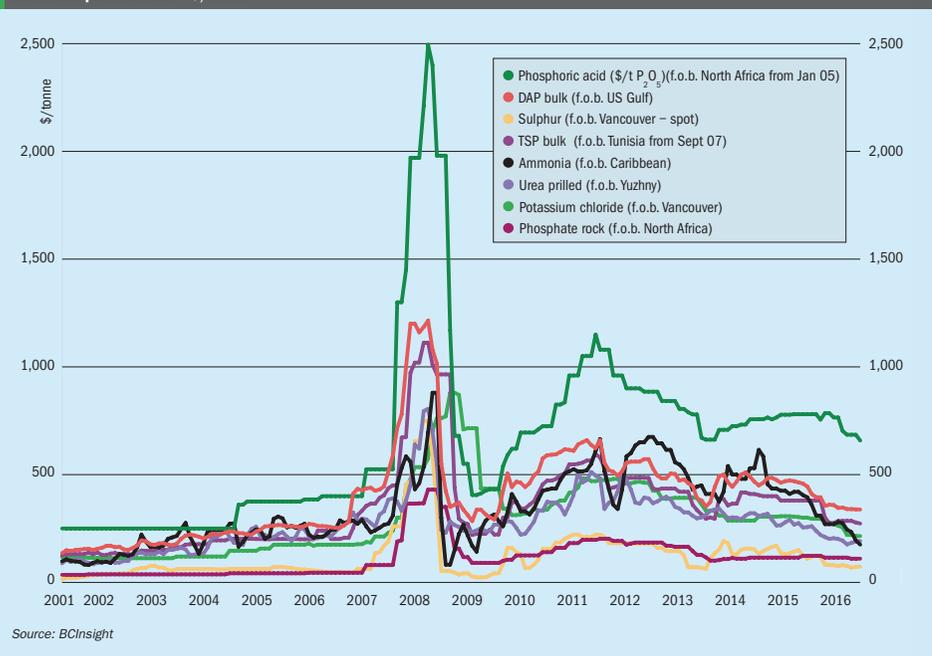
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Historical price trends \$/tonne



Market insight courtesy of Integer Research

AMMONIA

Global prices continued to tumble in September and October. This was linked to poor market sentiment driven by capacity additions in the US and diminished seasonal buying. The Yuzhny ammonia price ended October on \$167/t, down \$6/t on September and almost \$225/t year-on-year. Falling prices are even putting low-cost Russian producers under pressure. They posted an estimated \$25/t loss on sales in October, despite a weak rouble keeping their gas and ex-works ammonia costs competitive. TogliattiAzot has responded to the exceptionally weak ammonia market by considering taking six of its ammonia units offline and restarting a urea line instead.

UREA

The urea market shows some signs of stabilising. Prices have been bolstered by the temporary supply shortages affecting most key export regions, falling Chi-

nese exports, and a tender for nearly one million tonnes of urea from India. Rationalisation in China has been the key supply-side driver behind the recent urea price upswing. A shortening of the Chinese domestic coal market has led to higher nitrogen costs by triggering coal price rises. Over 70% of China's urea capacity is coal-based and, at urea prices of under \$200/t, a significant proportion of this capacity is loss-making. Chinese utilisation rates continue to fall and were just 52% in September, reflecting permanent plant closures and idle capacity. As a consequence, Chinese urea exports fell by 31% year-on-year in September to 676,383 tonnes.

PHOSPHATES

Headwinds continued to buffet phosphates markets in October. Month-on-month finished product prices were flat to soft across the major global hubs. Demand is generally tepid and supply remains excessive. The start of the Indian

rabi crop season has done little to support phosphate imports. Indian buyers were generally well covered, allowing them to hold out for price reductions. The average DAP import price to India (\$318/t cfr) was down in October, the thirteenth consecutive monthly price fall.

In China, weak domestic and export demand has left 300,000 tonnes of finished phosphates at ports. Margins continued to erode with Chinese exports averaging \$305-310/t f.ob.

On the supply side, Middle East and North Africa producers were largely sold out of product for October after making sales to Pakistan, Turkey and Africa. Producer margins came under pressure as falls in raw materials prices were outweighed by lower phosphate prices.

POTASH

Market sentiment has improved in recent months as the supply situation has become more balanced. The market floor was reached in July and potash prices have generally stabilised since then. Prices even showed signs of slight firming

in Southeast Asia and Brazil due to limited spot availability from some producers.

Baltic MOP prices have stayed level at \$218/t f.o.b. since mid-July, while Vancouver MOP price increased slightly to \$230/t f.o.b. in early September, and have maintained that level throughout October. Average MOP prices in Brazil reached \$238/t cfr in mid-October, up \$10/t on August. Southeast Asian MOP prices rose from \$240/t cfr in mid-August to \$248/t cfr in mid-October.

SULPHUR

After reaching a floor in August, sulphur prices have been rising through September, October and into November. The main driver has been the comfortable short term positions of producers in the Middle East. Price postings have risen above \$80/t f.o.b. Middle East for November shipments. Downward pressure from the processed phosphates market has not greatly affected sulphur producer senti-

ment. Global sulphur production increased by around 6% in 2016, with the Middle East usurping North America as the number one regional producer during the year. The main factor has been the Al Hosn Shah gas project adding 3 million tonnes to the export market in 2016. This has increased the UAE's sulphur market share in Morocco, Brazil and China. On the consumption side, fresh sulphur demand has emerged in Cuba due to the start-up of Sherritt's sulphuric acid plant.

Market price summary \$/tonne – Early-November 2016

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phosphoric Acid
f.o.b. Caribbean	175	n.m.	f.o.b. E. Europe 80-90	f.o.b. US Gulf	325	n.m.	n.m.
f.o.b. Yuzhny	160-165	197-200	-	f.o.b. N. Africa	338-348	265-280	505-810
f.o.b. Middle East	150-162	208-225**	-	cfr India	308-317	-	580*
Potash	KCl Standard	K ₂ SO ₄	Sulphuric Acid	Sulphur			
f.o.b. Vancouver	190-240	-	cfr US Gulf	35-45	f.o.b. Vancouver	73-78	
f.o.b. Middle East	185-240	-			f.o.b. Arab Gulf	77-82	
f.o.b. Western Europe	-	€440-460			cfr North Africa	67-78	
f.o.b. FSU	180-235				cfr India	92-95+	

Prices are on a bulk, spot basis, unless otherwise stated. (* = contract ** = granular). Phosphoric acid is in terms of \$/t P₂O₅ for merchant-grade (54% P₂O₅) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf) Copyright BCInsight

MARKET DRIVERS

- **Ammonia outlook:** The global market looks set to remain long for the rest of the year due to weak demand and US capacity additions. Incitec Pivot's new ammonia plant in Waggaman, Louisiana, for example, is likely to operate at 80% of its 720,000 t/a capacity during its first year. Global ammonia demand also looks weak, until sizable demand begins to kick-in next February and March ahead of spring applications in North America and Europe.
- **Urea outlook:** Price levels are forecast to move up in November amid temporary short positions in the key exporting regions. Chinese urea suppliers are expected to increase their export offers in November, the main factors being falling utilisation rates, increased coal feedstock prices and rising domestic prices. Only moderate urea price increases are expected, as a substantial supply overhang remains, not least in China. The US urea market will be tighter than expected because of the delayed start-up of CF Industries' Port Neal plant.
- **Phosphates outlook:** Upside potential in the processed phosphates market will be limited in the fourth quarter. Sluggish

Indian demand means competition for export volumes to India remains high.

The large volumes available for export at Chinese ports present the largest downside price risk for ammonium phosphates. There is little upside for Chinese producers currently, as domestic demand is weak and Chinese plants have been running at 50-55% capacity.

The US domestic market is subdued and barge activity is expected to slow in coming months. US Gulf f.o.b. prices will come under pressure as imports from Europe, North Africa, Russia and China compete for a slice of the domestic market. Brazilian MAP demand is expected to remain stable for the remainder of the year, with availability from major exporters keeping prices in check.

- **Potash outlook:** We expect potash prices to remain stable with the potential to firm slightly in November and December. Producers have been quick to raise their price targets in response to improved market conditions and possible unmet demand. For Brazil, producers are targeting \$240-245/t cfr for December but these levels have yet to be achieved.

The moderate supply shortage is unlikely to extend beyond the fourth quarter. Demand is expected to taper

off in Brazil and other key importing countries, shifting market supply back to balanced or long. In Southeast Asia, an anticipated recovery in the region's oil palm output looks set to boost fertilizer demand and support prices.

- **Sulphur outlook:** Prices look set to stabilise after recent rises. Qualms about passing on increased raw material costs could even lead to a downward correction by the year's end. The outlook looks more bearish in 2017 with new sulphur supply coming online in the Middle East and the FSU. The Barzan project in Qatar has been delayed due to technical issues. But the project will add over 800,000 t/a of sulphur to supply when its two phases start operating. In Kazakhstan, the Kashagan project is also now scheduled to start-up in the first quarter of 2017. In China, meanwhile, strong sulphur imports during 2016 have helped support trade and pricing. Domestic sulphur output is set to rise in China, however. Any resulting decrease in imports would have a negative impact on pricing, if new markets cannot be found. Looking at the phosphates outlook, new capacity additions in Saudi Arabia and Morocco means the market for finished products is likely to remain long next year.

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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MOROCCO

OCP licenses Shell Thiogro technology

Panoramic view of Jorf Lasfar.

PHOTO: SHELL



OCP will start to produce sulphur-enhanced fertilizers next year using Shell Thiogro technology under license.

The strategic deal was jointly announced by OCP and Shell on 22 September. It permits the installation of Shell Thiogro technology at OCP's Jorf Lasfar site. This will allow the company to incorporate micron-sized particles of elemental sulphur into its existing fertilizer products, including ammonium phosphates and NPKs.

"Shell Thiogro technology will enable OCP to produce highly concentrated sulphur-enhanced fertilizers, helping end-users unlock even greater crop yields and improve soil health," the company said in a statement.

The deal is an important move by OCP as it will add new and potentially highly-lucrative premium products to its existing fertilizer range. Its US competitor Mosaic has successfully reconfigured its phosphates operations to produce increasing volumes of *MicroEssentials*, a premium NP+S product that also contains zinc. Production of *MicroEssentials*, which is manufactured using patented *Fusion* technology, surpassed one million tonnes in 2014.

"This partnership with Shell will bring us one step closer to achieving our goal of offering farmers a wide selection of custom-

ized products tailored to the specific needs of their soils," said Mustapha El Ouafi, OCP's managing director.

Michael Lumley, vice president of Shell Sulphur Solutions, added: "We are pleased to license our Shell Thiogro technology to OCP, one of the world's leading fertilizer producers, whose efforts continue to contribute to improved food security in Africa and across the globe."

Shell's sulphur-enhanced fertilizer production technology is due to be installed and commissioned in 2017.

OCP is continuing to expand production capacity at its Jorf Lasfar site. The one million t/a Africa Fertilizer Complex officially opened at Jorf Lasfar in February and a second identical capacity unit became operational over the summer.

In October, OCP also unveiled plans to build a 1.2 million t/a capacity NPK plant in Andhra Pradesh, India, as part of a 50:50 joint venture (JV) with Kribhco. The two partners will initially invest around \$230 million developing the plant and related infrastructure in and around the port of Krishnapatnam. This is just the first step and Kribhco may invest in a phosphoric acid plant in Morocco, as part of a broader strategic partnership between the two companies.

OCP also signed an agreement to build a fertilizer blending unit in Rwanda in October. ■

UNITED STATES

Mosaic plans to plug New Wales sinkhole

Mosaic is working on a plan to plug the sinkhole discovered at its New Wales site in Mulberry, Polk County, Florida.

The sinkhole, which formed underneath a collection pond in a gypsum stack, released 215 million gallons of process water into an underlying aquifer. It was 220 feet deep and 40-150 feet wide according to remote sensing measurements made in mid-October.

Mosaic says it is considering using a "concrete-like grout" to seal the pathway that has opened into the aquifer.

Mosaic was first alerted to the sinkhole on 27 August when monitoring systems detected a water level drop in a process pond on top of its south gypsum stack at New Wales. Subsequent testing confirmed water loss from a process pond in the stack's west compartment.

"We promptly notified Florida Department of Environmental Protection (FDEP), the US Environmental Protection Agency (EPA), and Polk County, and started the process to remove water from the affected

process pond," Mosaic said.

Mosaic is using a 24 inch wide and 800 feet deep recovery well to capture the process water lost as a result of the sinkhole. This is removing water out of the affected aquifer at a location west of the gypsum stack. Water is moving westwards in the aquifer at around 500 feet per month. Mosaic is confident that the lost process water can be recovered and that the well is performing as expected. "That pace allows us to recover water from the gypsum stack by pumping it through our well," it said.

Mosaic is certain that "there have been no off-site consequences from this event".



Sinkhole at the New Wales site.

It has established an extensive groundwater testing programme in the surrounding area to monitor for possible process water contamination. The company has visited and taken water samples from 1,142 sites and scheduled a further 1,234 independent well tests, as of 1 November. It is also offering free bottled water to local residents and has received over a 1,000 requests for these to date.

Mosaic signed a consent order with the FDEP over the remediation of the sinkhole on 24 October. "Ensuring the safety of our community and employees, and the proper management of environmental resources, continues to be our top priority as we remediate the sinkhole," said Walt Precourt, Mosaic's senior vice president for phosphates. "From the beginning, Mosaic has been committed to keeping the water from the sinkhole on-site with no community impacts, and we continue to fulfil that commitment."

Mosaic says it is working "around the clock to review the situation, and our response to it". It expects to complete remediation work on the sinkhole by spring next year.

TSI launches sulphur fertilizer website

The Sulphur Institute (TSI) has launched a new website as an information resource on the production, marketing and use of sulphur fertilizers.

"Sulphur is now increasingly recognized for its role as an essential element for the efficient production of food, thereby enhancing farmers' ability to meet the nutritional needs of an expanding global population. TSI is committed to sharing this critically important information," said Robert McBride, TSI president and CEO. "This website is only part of a larger outreach program conducted by TSI and we invite all sulphur stakeholders to actively participate."

The site, called *Sulphur - The Fourth Plant Nutrient*, is available at www.SulphurInstitute.org/Fertilizer.

BRAZIL

Vale yet to confirm fertilizer sell-off

Vale's board of directors approved the sale of its fertilizer business in late October, according to Brazil's *Valor Economico* newspaper.

The news follows earlier reports by *Bloomberg* that Vale's fertilizer business will be sold to US producer Mosaic for \$3 billion, except for Vale's fertilizer plants in Cubatão, São Paulo state, which will be sold to Yara International for \$600 million. Mosaic is believed to have been discussing the purchase of Vale's fertilizer business since the summer.

Vale is the world's largest iron ore producer and the largest producer of phosphates in Brazil. Reports that it has sold its fertilizer business remain speculative, as none of the three firms involved have commented on or confirmed the details.

UNITED KINGDOM

Sirius Minerals sets January start-date

Sirius Minerals says it will start building its UK-based North Yorkshire polyhalite project in January next year, after unveiling a new finance package on 2 November.

The company will raise \$900 million for the project using a combination of equity and loans.

The new finance package includes a share placing and offer worth £330-400 million (\$400-490 million) and a convert-

ible bond offer worth \$400-450 million, both fully underwritten by JP Morgan Cazenove. Some 90% of the shares being placed will go to institutional investors.

This dual approach seems to have worked successfully. Sirius Minerals subsequently announced that it had successfully raised gross proceeds of £370 million from the placing of shares, and successfully placed \$400 million of convertible bonds.

"The completion of the convertible bond and equity placing is great news for the company, and delivers the financing that allows us to start construction of our North Yorkshire polyhalite project," said Chris Fraser, the managing director and CEO of Sirius Minerals.

Under its 'Stage 1' financing plan, Sirius Minerals needs to raise around \$1.2 billion to build the first phase of the mine. The company secured the additional \$300 million it needs through a separate royalty-based deal with Hancock Prospecting on 25 October.

Hancock, owned by Australia's richest woman Gina Rinehart, is paying \$250 million in exchange for 5% of gross royalties on the first 13 million tonnes of future fertilizer sales, and also receives a 1% royalty rate on sales above that level. This is topped up by \$50m of equity that Hancock is also putting into the project.

The new finance package will need to be agreed by Sirius Minerals shareholders at a meeting on 25 November. Chris Fraser said the company would "start mobilising contractors" as soon as shareholder



Sirius minerals exploration drill rig.

PHOTO: KEANE CUNNINGHAM

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
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Industry professionals celebrate Global Fertilizer Day.

backing was secured. "The first piece of works on the ground will be in January on highways improvements," Fraser told the UK's *Daily Telegraph* newspaper.

London launch for Global Fertilizer Day

The first ever Global Fertilizer Day was officially launched in London on 13 October.

The event, a celebration of the 50% contribution fertilizers make to world food production, garnered wide international support, including the backing of Fertilizers Europe, the International Fertilizer Association (IFA) and The Fertilizer Institute (TFI).

October the 13th was chosen as it marks the anniversary of the submission of the Haber-Bosch patent in 1908. This date is highly symbolic as it arguably represents the founding moment for today's modern fertilizer industry. It also salutes the emergence of an invention which has single-handedly revolutionised agricultural productivity.

Global Fertilizer Day is needed to help reduce the gulf between consumers and agriculture, as OCI Nitrogen's Marc van Doorn explains: "There has never been a more prominent distance between the farmer and the consumer than today. The fact is that most of the world does not know where their food comes from and how it is grown. We need to remind ourselves that food sustainability is not achievable on its own and it's crucial that we connect the population to their sources of food."

A group of international agriculture professionals marked the inaugural Global Fertilizer Day by gathering at the Farmers Club in central London to discuss fertilizer innovation. Rothamsted Research Centre in Harpenden, the world's oldest continuously running agricultural institute, also hosted a curtain raiser event on the 12 October.

EGYPT

Phosphates factory JV agreed

Belgium's EcoPhos and Egypt's Evergrow have formed an equal partnership to build a feed phosphate and fertilizer factory in Sadat City, north-west of Cairo.

Evergrow's chairman, Mohamed El-Kheshen, and Mohamed Takhim, the CEO of EcoPhos, signed a joint venture (JV) agreement for the factory on 20 October. Its construction will require an investment of \$120 million.

The planned factory will produce 110,000 t/a of dicalcium phosphate (DCP) for the animal feed market and 100,000 t/a of single superphosphate (SSP) fertiliser. A sulphuric acid plant (600 t/d) and calcium chloride plant (60,000 t/a) also form part of the planned complex.

The factory will supply domestic and regional markets and will use innovative proprietary technology developed by EcoPhos. The Belgian company will also supply basic and detailed engineering and equipment for the project. The factory's DCP output be sold and distributed by Aliphos,

the feed phosphate subsidiary of EcoPhos.

Earlier in October, EcoPhos signed a INR 5.26 billion (\$79 million) deal with Gujarat Narmada Valley Fertilizers & Chemicals (GNFC) Ltd to build a 200,000 t/a DCP plant in Dahej, India. EcoPhos also officially opened its Technophos technology centre in Varna, Bulgaria, in September.

The €60 million 220,000 t/a capacity DCP plant being built by EcoPhos near Dunkirk in France is due to be completed in March next year.

NETHERLANDS

ICL starts CRF production at Heerlen

ICL Specialty Fertilizers has begun producing controlled release fertilizers (CRFs) using a new 25,000 t/a production line at its Heerlen site in the Netherlands. The CRFs have been manufactured using the company's new *E-Max* release technology and will be marketed under the *Agromaster* and *Agrocote Max* brand names.

E-Max has been developed at ICL's R&D facility in the Netherlands over several years and has been tested worldwide. The technology releases nitrogen, potassium and phosphate in a much more precise manner, according to ICL.

"We have developed a unique process and technology for adding a very thin coating to a fertilizer granule," said Leon Terlingen, R&D director at ICL Specialty Fertilizers. "The new thin coating allows us to keep the

nutrient level very high, while also assuring a very good release curve for the crops."

CRF use is expected to grow rapidly worldwide. Although initially used for ornamental crops and turf, CRFs are increasingly being applied to a wide range of crops including vegetables, fruit, maize, potatoes, rice and sugarcane.

"There is a strong trend towards precision nutrition as growers experience the added value of these products," commented Fred Bosch, ICL's senior vice president of specialty fertilizers for Europe & Asia Pacific. "The results I have seen during my visits to field trials and to growers who use our product have been very good, with higher yielding and better quality crops and fewer fertilizer applications."

The production line at Heerlen is the latest step in ICL's expansion and growth plan for CRFs. The company began production using the technology at Summerville in the US in 2014 and has well-advanced plans for new CRF production plants in Asia and Latin America.

KAZAKHSTAN

EuroChem signs fertilizer investment MoU

EuroChem has committed to further investment in fertilizer production in Kazakhstan under a new Memorandum of Understanding (MoU) with the country's authorities. This formalises EuroChem's plans to construct a fertilizer production complex near its existing phosphate rock mine in Kazakhstan's Jambyl region.

EuroChem signed the memorandum with ministerial and regional administrators during a recent Russia-Kazakhstan cooperation forum held in Astana. The forum was attended by the respective presidents of Kazakhstan and Russia, Nursultan Nazarbayev and Vladimir Putin.

As part of the MoU, Kazakhstan's state and regional authorities have pledged to provide a supportive legal and business environment for EuroChem's project plans. In return, EuroChem has promised to contribute financially to improving social and transport infrastructure in the country.

EuroChem is one of the largest investors in Kazakhstan. It has been developing a phosphate rock mining and fertilizer production project in the country's Jambyl region since 2013. The project's first stage, the building of phosphate rock mine, has been successfully completed, with output now running at 640,000 t/a since the start of 2016. EuroChem has also invested \$18 million in the region's social and economic development to date.

EuroChem plans to increase phosphate rock output from the mine to 1.5 million t/a during the second stage of the project. The construction of a

fertilizer complex with a potassium sulphate and dicalcium phosphate capacity of one million t/a is also planned as part of the project's second stage. The complex will also produce one million t/a of by-products.

Dmitry Strezhnev, EuroChem's CEO, praised Kazakhstan for supporting the company's activities: "The signing of the memorandum is an important and logical step in helping us implement one of our strategic projects. This demonstrates that we remain committed to continuing the implementation of our project, further improving the region's social and transport infrastructure and broadening this private-public partnership."

EuroChem recently opened a new fertilizer distribution centre in Hungary, as part of a wider strategic expansion into Central and Eastern Europe. The new centre will distribute premium fertilizers and other EuroChem products. It will also distribute specialty fertilisers produced by Fertilia Ltd, a leading Hungarian fertilizer company.

EuroChem also signed a new \$800 million pre-export finance facility with 12 leading international banks in September. The company will use the proceeds to refinance part of its debt, including the full repayment of a previous pre-export facility dating from August last year.

NIGERIA

Abraaj Group buys into Indorama Fertilizers

Dubai-based Abraaj Group has acquired a minority stake in Indorama Fertilizers, the largest urea producer in Sub-Saharan Africa. Indorama's assets include the recently-commissioned 1.4 million t/a Eleme urea plant at Port Harcourt, Nigeria.

Abraaj says it will use its expertise and networks to support Indorama's market penetration and expansion plans. The group has been active in Africa for two decades. It currently holds investments worth \$3 billion in the continent's healthcare, financial services, logistics and consumer sectors.

Commenting on the investment, Arif Naqvi, Abraaj Group's founder and CEO, said: "We are privileged to be partnering with Indorama Corporation to create a global fertilizer leader in Africa. Having successfully invested in the fertilizer business in North Africa, we look forward to leveraging that know-how and working with the management team in developing the company's route-to-market... build its network and support its capacity expansion and product diversification plans."

In response, Sri Prakash Lohia, Indorama Corporation's founder and chairman, said: "We are pleased to welcome The Abraaj Group as an investor in our fertilizer business as we endeavour to create a world-class manufacturing and distribution network for fertilizers in the African continent."



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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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People

ICL's board of directors appointed **Asher Grinbaum** as interim CEO on 11 September. His appointment follows the resignation of the previous CEO **Stefan Borgas** for personal reasons. German-born Borgas said: "After four successful years of leading ICL through a historically dramatic downturn of the commodity industry, I feel that it is time for me to move the centre of my life back to Europe." Grinbaum, who has worked for ICL for over 40 years, will act as CEO until a permanent replacement is found. He holds a mechanical engineering degree and MBA from Ben Gurion University, and was previously the company's executive vice president and chief operating officer.

The Fertilizer Institute (TFI) has hired **Dr Sally Flis** as its director of agronomy. This is a new position created to support the institute's agronomic work, particularly the adoption of 4R nutrient stewardship in the US. Dr Flis will also support TFI's sustainability programmes and provides guidance to TFI's government and public affairs department on policy, legislation, publications and outreach.

Dr Flis has worked in agriculture for more than 15 years, most recently as the feed and crop support specialist at Dairy One in Ithaca, New York.

"In the last six years, adoption and support for the 4R Nutrient Stewardship program has grown tremendously, and we continue to see widespread growth as growers and the fertilizer industry work to increase yields while minimising environmental impact,"

said Chris Jahn, TFI president. "The addition of Sally to the team gives us the needed bandwidth and experience to continue to support TFI members, growers, and other stakeholder organisations in their implementation of 4R principles in the field."

The Sulphur Institute (TSI) has appointed **Kerry Kurowski** as its senior manager for meetings, member relations and office services. "We look forward to Kerry's meeting planning experience and her additional skills which will enhance programs and operations," said Robert McBride, TSI president and CEO. Kerry has worked in the events industry since 2002. She is a certified meeting professional and has a bachelor's degree from the University of Maryland

Trammo, Inc. has named **Brent Hart** its new CEO. He will work out of Trammo's Denver, Tampa and New York offices. Hart has been with the company for 22 years, serving in senior trading and management roles, and was previously president of Trammo's commodities division. He currently sits on the board of directors of TFI.

Dr Kalle Härkki is the new president of Outotec's metals, energy & water business unit. He will also serve as an executive vice president of the company. Dr Härkki has been a member of Outotec's board since 2008, initially as head of the services business area and subsequently as head of the minerals processing business unit since 2013.

Jyrki Makkonen, who has been acting head of Outotec's metals, energy & water business since April 2016 will return to his

position as head of the non-ferrous business line. **Taneli Salervo**, the current vice president for strategy & business development, will lead the minerals processing business unit until a permanent successor to Dr Härkki has been appointed.

"I am very glad that Kalle Härkki, who has a long and versatile experience in leading Outotec businesses, accepted the position as head of metals, energy & water. I would also like to thank Jyrki Makkonen for leading the metals, energy & water business in the interim," said Markku Teräsvasara, Outotec's CEO.

Dr James Trainham, chief technology officer at JDC Phosphate, will receive the AIChE's prestigious 2016 Industry Leadership Award in November. Dr Trainham will receive the award at the AIChE's Annual Meeting in San Francisco, after being selected by its board of directors.

The award recognises the innovation and technical creativity displayed by Dr Trainham throughout his career, including his current work commercialising the Improved Hard Process for phosphoric acid production. Dr Trainham, who has been a fellow of the AIChE since 2012, has more than 40 patents and publications to his credit. His previous honours and awards include election to the US National Academy of Engineering, receiving the AIChE's Award for Chemical Engineering Practice in 2002, and being selected as "one of the 100 chemical engineers of the modern era" in 2008.

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31-2 FEBRUARY

23rd AFA Annual International Fertilizer Forum & Exhibition, CAIRO, Egypt
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FEBRUARY

27-30

IFA Global Safety Summit, AMMAN, Jordan
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MARCH

13-15

Phosphates 2017, TAMPA, Florida
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MAY

8-10

SYMPHOS 2017, 4th International Symposium on Innovation in the Phosphate Industry, BEN GUERIR CITY, Morocco

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22-24

85th IFA Annual Conference, MARRAKECH, Morocco
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JUNE

9-10

41st AIChE Annual Clearwater Conference 2016, CLEARWATER, Florida

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A merger of equals?

The proposed Agrium-PotashCorp merger would create a Canadian fertilizer giant worth more than \$25 billion. Agrium's large network of retail stores in the US, Canada, Australia and South America would provide PotashCorp with valuable farm access for its products. The massive company created by the merger would also be a dominant force in North American fertilizer production, controlling 62% of potash capacity, 30% of phosphate capacity and 29% of nitrogen capacity, according to some estimates.

For fertilizer producers, the need to maintain margins and improve operational efficiency is a business imperative. This is especially true in an over-supplied market at a time of falling prices. Mergers and acquisitions (M&A) offer an obvious short cut in the quest to cut costs, gain market share and create extra value.

In recent years, however, a number of large mergers between major fertilizer producers have fallen by the wayside and failed to complete. The proposed nitrogen industry merger between OCI and CF Industries, for example, fell apart in May after the US Treasury moved to tighten corporate tax rules.

PotashCorp's €7.8 billion offer for Germany's K+S was also withdrawn last year after the two potash producers failed to agree on price. Going back to 2010, the Canadian government blocked the \$39 billion takeover of PotashCorp by BHP Billiton, the world's largest mining company.

Despite this, many analysts still judge that, in the current market environment, fertilizer industry consolidation is long overdue, even inevitable. The recent news that two of the fertilizer sector's major North American players, Agrium and PotashCorp, are set to merge was therefore not entirely unpredictable.

"We have written at length about the need for consolidation in both the nitrogen and potash markets, and we think this merger makes sense in both cases," commented Integer Research. "Indeed, following recently terminated merger discussions... it was [only] a matter of time before the next... industry M&A."

Equal but different

Confirmation of the planned merger came in a joint Agrium-PotashCorp statement on 12 September. Described as "a merger of equals", the integration of the two firms, if

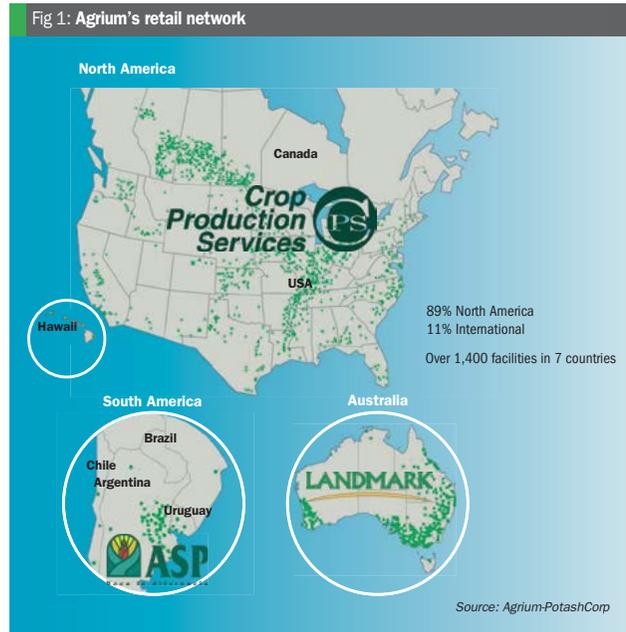
successful, will create the world's largest crop nutrient company and the third largest natural resource company in Canada.

The deal was unanimously approved by the boards of directors of both companies. PotashCorp shareholders should own a 52% majority stake in this new (but as yet unnamed) parent, if the deal goes through, with Agrium shareholders taking a slightly lower 48% stake.

"Our merger creates a new, premier, Canada-headquartered company that reflects our shared commitment to creating value and unlocking growth potential,"

said Jochen Tilk, PotashCorp's CEO and president. His comments were mirrored by Chuck Magro, Agrium's CEO and president: "This is a transformational merger that creates benefits and growth opportunities that neither company could achieve alone."

Magro is set to become the CEO of the merged company whilst Tilk will become its new executive chairman. The current finance directors of both firms, PotashCorp's Wayne Brownlee and Agrium's Steve Douglas, have been named as chief financial officer and chief integration officer, respectively.



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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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Retail strength versus production might

PotashCorp and Agrium are similar size companies with market capitalisations of \$13.43 billion (CAD 17.54 billion) and \$12.32 billion (CAD 16.10 billion), respectively, as of 29 August. They also generate broadly equivalent earnings. But these similarities are deceptive, as they mask very different revenues, gross profits and margins – a reflection of their very different business models.

Agrium operated on a 14% margin, earning \$2.1 billion (EBITDA) last year on revenues of \$14.8 billion. PotashCorp, in contrast, achieved a 45% margin in 2015 by making slightly higher earnings (\$2.6 billion EBITDA) on much lower revenues (\$5.8 billion). Gross profits for 2015 were \$3.9 billion for Agrium versus \$2.3 billion for Potash.

PotashCorp remains at heart a large-scale miner. So it is unsurprising that around 58% of its gross profit last year came from potash sales. These were topped up by profits from its nitrogen (31%) and phosphate (11%) sales. Most of Agrium's 2015 gross profit (71%), in contrast, came from retailing.

The retail and wholesale parts of Agrium's business are fairly evenly balanced. Around 45% of Agrium's earnings last year (\$2.1 billion EBITDA) came from selling crop nutrients, crop protection products, seeds, merchandise and agricultural services through its retail arm. The wholesale production, marketing and distribution of more than nine million tonnes of nutrients generated the other 55%. Agrium's wholesale earnings in 2015 (around \$1.2 billion EBITDA) were mainly from nitrogen production (71%) supplemented by potash (16%) and phosphate (13%) output. Its total fertilizer production is set to rise to 10.5 million tonnes next year.

The commercial rationale for the merger hinges on the complementary strengths of each business. On paper, linking-up PotashCorp's upstream might in potash production with Agrium's downstream retail presence makes financial and business sense. Put simply, PotashCorp, the world's largest crop nutrient company, makes fertilizers on a very large scale and Agrium, the largest agricultural retailer on three continents, has the international storefront to sell these.

Only future market developments will reveal whether the move is truly a merger of equals.

"A merger of equals is rarely so, and this deal will favour one party over the other depending on how the coming years play out," comments analysts CRU. "If Agrium sees a sustained recovery in fertilizer prices, PotashCorp's wholesale assets would be a great way to cash in. [But] if PotashCorp sees a prolonged depression then it will be Agrium's retail arm that can deliver underlying stability through the bad times in a cyclical fertilizer market."

When two become one

The merger does have clear mutual benefits. Retail access via Agrium's network of more than 1,400 outlets in the US, Canada, Australia and South America (Figure 1) has obvious attractions for PotashCorp.

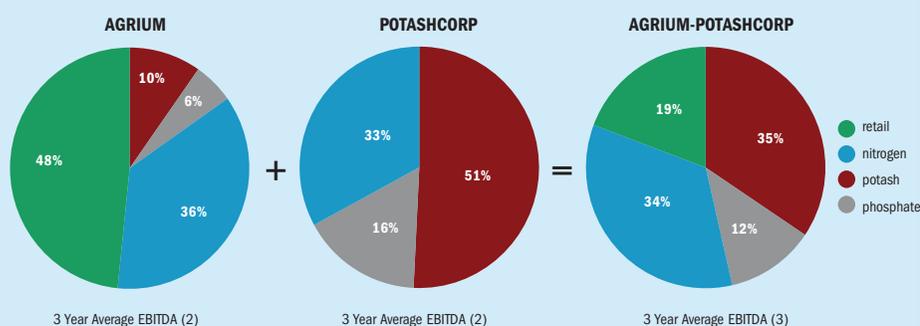
Unification would also add to and broaden Agrium's wholesale manufacturing capabilities by bringing together around 29 million t/a of production capacity, creating a fertilizer product mix of roughly two-thirds potash, one-quarter nitrogen and one-tenth phosphate.

In terms of the future income of the new business, potash and nitrogen production are likely to generate a one-third slice of earnings each, with another fifth of earnings coming from the retail side. Phosphates looks set to remain a minor segment, generating about an eighth of earnings (Figure 2).

The merged company would have close to 20,000 employees. Although predominantly North American, it would also have a widespread international presence through operations and holdings in some 18 countries. PotashCorp has a particularly large international investment portfolio, owning sizeable stakes in Jordan's APC (28%), Israel's ICL (14%), China's Sinofert (22%) and Chile's SQM (32%).

Based on PotashCorp and Agrium's recent financial performance, the new company would bring in annual revenues of \$20.6 billion and generate earnings (EBITDA) of \$4.7 billion annually. The market capitalisation and enterprise value of the combined business is likely to be around \$26 billion and \$36 billion, respectively.

Fig 2: Earnings breakdown (EBITDA, three-year average) for Agrium, PotashCorp and the merged company



Source: Agrium-PotashCorp

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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Fig 3: Agrium and PotashCorp's potash operations

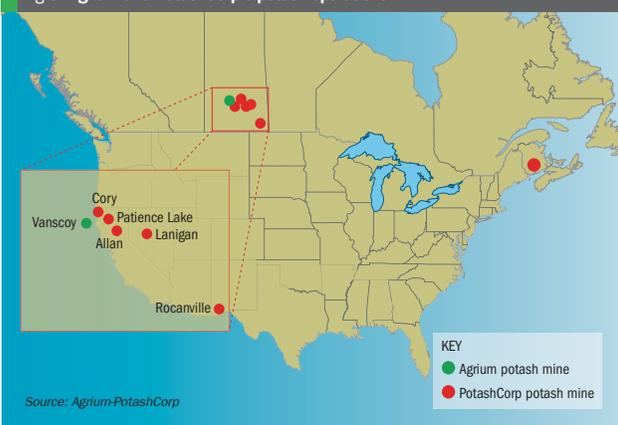
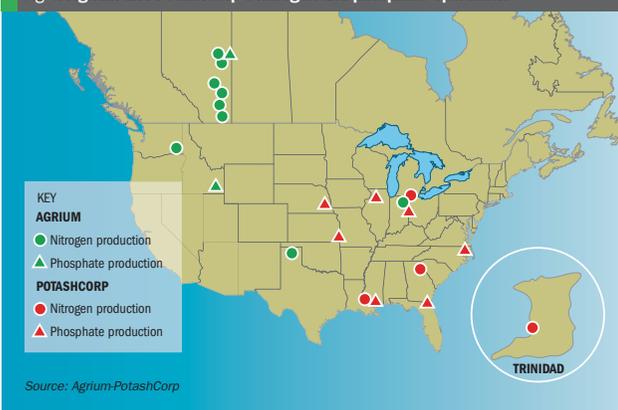


Fig 4: Agrium and PotashCorp's nitrogen and phosphate operations



Consolidation of assets

The merger will create a North American fertilizer giant with around 29 million tonnes of production capacity.

Bringing Agrium and PotashCorp together would result in a significant consolidation of Canada's potash industry. It would also reinforce PotashCorp's existing status as the world's leading producer with a one-fifth share of global potash capacity. For potash alone, the new company is expected to have a total nameplate capacity of 19.1 million tonnes with the prospect of a further three million tonnes of incremental capacity coming on-stream in future. PotashCorp currently operates 14 million t/a of potash capacity

in Saskatchewan spread across five mines (Allan, Cory, Lanigan, Patience Lake and Rocanville). Agrium brings to the table its recently-expanded three million t/a Vanscoy potash mine in the province (Figure 3).

Additionally, by consolidating other significant American assets, the new company will emerge with 7.7 million tonnes of nitrogen nameplate capacity and 2.6 million tonnes of phosphate nameplate capacity.

Agrium currently owns 5.8 million tonnes of nitrogen capacity in the Americas. It operates four nitrogen plants in Alberta, Canada (Redwater, Carseland, Ft Saskatchewan and Joffre), another in Borger, Texas, and also owns a 50% stake in Profertil's Bahia Blanca urea plant in

Argentina. PotashCorp has three US nitrogen plants (Augusta, Georgia, Geismar, Louisiana and Lima, Ohio) and another in Trinidad (Figure 4).

On the phosphates side, Agrium operates two North American plants with a combined capacity of 1.2 million tonnes, namely the 660,000 t/a Redwater plant in Alberta and the 500,000 t/a Conda plant in Idaho – both of which mainly produce MAP. PotashCorp's North Carolina Aurora plant will provide another 360,000 t/a of MAP and 840,000 t/a of DAP capacity (Figure 4).

One consequence of the merger would be to bring roughly 1.7% of North American DAP/MAP capacity together under one roof, according to Argus FMB. Such a development would be the latest in a series of consolidations and closures that have characterised the US phosphates sector since the early 2000s.

"For Agrium, the merger gives it access to a larger portfolio of production assets and some logistical gains in its retail supply chain," sums up analysts CRU. "Its facilities at Redwater and Conda (phosphate) and Vanscoy (potash) may be idled in favour of PotashCorp's lower-cost operations."

Adding \$5 billion value

The fusion of Agrium and PotashCorp into a single enterprise brings with it the chance to reduce operating costs and improve margins – a key issue given the current low-price environment for fertilizers. Economies of scale, efficiency gains and avoiding duplication of effort should all deliver cost reductions.

The multibillion dollar outlay in three particular areas, freight and distribution, capital spending and procurement, offers major cost saving opportunities – 'synergies' in business parlance.

Agrium and PotashCorp's combined freight and distribution costs total \$1.2 billion annually, for example. Together, the two firms make 16.5 million tonnes of North American product shipments each year, freighted by 15,000 railcars to more than 1,700 distribution points. Their combined sustaining capital also runs to \$1.2 billion annually. The \$1.4 billion jointly spent on non-raw material purchasing, maintenance, repair and operations represents another significant expense.

Teams at both companies have looked at major areas of expenditure and identified a total of \$500 million in achievable

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Key issues to be discussed

1 How are industry leaders ensuring their companies remain competitive in a downturn? What strategies can be applied to survive and thrive in a prolonged contraction?

2 How long will the market stay in oversupply? What new projects will make an impact? Where can capacity cuts be made?

3 How can more efficient and sustainable production make the industry stronger? Can innovative technologies or new approaches enable accelerated recovery?



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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
ISSUE 475
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Table 1: PotashCorp-Agrium merger: potential annual operational savings *

Category	Area	Description	Saving/synergy
Distribution & retail \$150 million	Rail fleet	<ul style="list-style-type: none"> Own/lease 15,000+ railcars at an average annual cost of \$115 million Shorter nutrient shipment times reduce costs by 20% 	\$25 million
	Distribution and warehouse	<ul style="list-style-type: none"> Eliminate duplicate warehouse locations, including \$20 million of Agrium warehouse costs 	\$25 million
	Logistics savings	<ul style="list-style-type: none"> Sourcing product closer to production facilities (product repatriation) Reduced freight costs 	\$50 million
	Portfolio integration	<ul style="list-style-type: none"> Channelling PotashCorp's crop nutrient production through Agrium retail Access to expanded product offerings 	\$25 million
	Product mix	<ul style="list-style-type: none"> Use retail network to optimise the nitrogen and phosphate product mix 	\$25 million
Production \$125 million	Phosphate integration	<ul style="list-style-type: none"> Use excess P₂O₅ capacity at PotashCorp Aurora and White Springs to supply and eliminate rock purchases at Agrium Redwater (\$70/t saving) 	\$80 million
	Potash cost efficiencies	<ul style="list-style-type: none"> Improved mine planning, turnaround optimisation and shift sequencing Expected to reduce cash fixed costs by 10% (\$4/t) 	\$45 million
Procurement \$100 million	Procurement	<ul style="list-style-type: none"> Optimise annual \$1.4 billion spent on non-raw material supplies and \$1.2 billion annual spending on sustaining capital Expected to reduce purchasing costs by 4% 	\$100 million
Selling, general and administrative (SG&A) \$125 million	SG&A expenses	<ul style="list-style-type: none"> End duplicate public company costs (listing fees, audit costs etc.) Cut discretionary G&A spending by \$60 million Reduced headquarter running costs 	\$125 million

*Approximate

Source: PotashCorp/Agrium

cost savings (Table 1). These breakdown as follows:

- \$150 million from distribution & retail
- \$125 million from production
- \$100 million from procurement
- \$125 million from Selling, General and Administrative (SG&A) expenses

Agrium and PotashCorp believe it should be possible to cut yearly costs by the full \$500 million amount from the end of the second year onwards, with approximately half these savings being achievable within 12 months of the merger. They estimate that these 'synergies' will ultimately create \$5 billion of extra value in the merged business, an increase of around one-fifth on their current combined market capitalisation.

"We think we'll create substantial synergies, \$500 million annually, \$5 billion in aggregate, and we think this is good for the farmers, it lowers costs, it creates efficiencies and ultimately that is good for our customers and it's good for the farmers," Jochen Tilk told *Financial Times* in September. Tilk also said there would be very few job cuts as a result of the deal: "Redundancies will be very small and not significant."

Agrichemical shake-out

The Agrium-PotashCorp merger is part of a wider industry consolidation that is cur-

rently underway. Dow Chemical and Dupont are combining in a \$130 billion deal, for example, whilst ChemChina is set to buy Syngenta for \$44 billion. Bayer is also hoping to buy Monsanto for \$56 billion.

These agrichemical consolidations are being driven by common factors, especially the underlying price weakness in crops, crop inputs and commodities in general. The crop nutrients industry, like the seeds and chemicals sectors, has seen its profit margins fall in recent times because of this. PotashCorp's earnings were hit hard by sluggish potash prices and fell 75% in the first half of 2016, reported *Financial Times*, while Agrium saw its net profits decline 18%.

The fact that seeds and fertilisers are the two largest variable costs for farmers may provoke some resistance to the Agrium-PotashCorp merger. "The consolidation of farmer suppliers might provide political pressure against the deal," Jonas Oxgaard, analyst at Bernstein told *Financial Times*, although he added: "Ultimately, we don't see this blocking it."

Jan Slomp, president of Canada's National Farmers Union, called for government intervention to halt the squeeze on farmers from the consolidation of crop input companies.

"That means reduced competition. Nitrogen fertiliser is probably the single

most handled commodity by Agrium and potassium by PotashCorp. Those are the two biggest fertiliser inputs that farmers are using," said Slomp, adding: "It is sure our governments stepped in and made sure that not everything is downloaded to farmers. The income situation of farmers has definitely gone down in the last few years."

Regulatory block unlikely?

Completion of the Agrium-PotashCorp merger still requires regulatory approval. But regulators are unlikely to view the merger as anti-competitive, according to analysts CRU, due to the lack of business overlap:

"[We do] not see a compelling argument to block the deal on competition grounds. PotashCorp has strength in its wholesale operations while Agrium relies predominantly on its retail operations, suggesting little overlap between the two companies' business."

Others analysts agree. "I don't think this merger would produce enough concentration in any commodity to raise regulators' concerns," comments Oliver Hatfield, a director at Integer Research. "This is an industry that has become much more competitive and where there has been a lot of over-investment in new capacity in response to the boom times."

Argus FMB believes that regulatory issues, if they do emerge, may come from US authorities not those in Canada: "It is too early to speculate about the reactions of US competition authorities, but it appears that there will still be a number of potash suppliers that have the ability to supply the US, despite the merger."

Any consolidation of the North American potash industry resulting from the Agrium-PotashCorp merger will in any case be partly offset next year by the arrival of competition in the form of the Legacy project, a new greenfield potash mine in Saskatchewan owned by German potash producer K+S. The merger is being interpreted by some analysts as partly a defensive measure in reaction to Legacy.

"These merger discussions could be seen as a defensive move in the North American market," comments Integer. "In light of the impending rise in competition from K+S's Legacy mine, Agrium's distribution channels in North America must be appealing to PotashCorp."

"From PotashCorp and the Saskatchewan's government's point of view, they would rather have PotashCorp and Agrium

merge as a defensive measure so that someone like BHP Billiton doesn't look at the low dollar and think, 'let's take another run at it'," Mark Warner, an antitrust legal expert at MAAW Law, told *Bloomberg*.

Blending of respective strengths

Analysts also appear to agree about the main motives behind the merger and its likely benefits.

"This is partly a defensive move by the companies – but it also makes sense in terms of vertical integration," comments Integer Research. "Agrium has been developing its downstream business over a number of years, and the newly merged company would likely benefit from pushing more N, P and K product through the supply chain."

CRU takes a similar line: "PotashCorp and Agrium likely see the merger as a way of blending their respective strengths in wholesale and retail. The consistent earnings of a retail business will be attractive to PotashCorp, while Agrium may be looking to tap into the future upside at PotashCorp, where earnings are closely linked with fertilizer prices."

Persuading shareholders of the merits of the merger – and whether the timing is right – has been critical. "Is now a good time for Agrium to shift its focus from retail to wholesale?" questions CRU. "Expanding the wholesale side of the business would be a bet on fertilizer prices recovering – but CRU believes this is still some way off."

Next moves

The good news for executives at both Agrium and PotashCorp is that their respective shareholders overwhelming backed the merger plans, by 98% and 99% respectively, at a meeting on 3 November. In both cases, this was well clear of the two-thirds majority needed for the deal to go through.

Now that this hurdle has been cleared, both firms expect to complete the merger by the middle of next year, subject to regulatory approval. Agrium and PotashCorp will therefore be encouraged that Ontario's Superior Court of Justice gave its approval to the merger on 7 November. Rulings by other regulators such as the Canadian Competition Bureau and the US Federal Trade Commission are still awaited. ■

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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Fertilizer Latino Americano

welcomes you to



Buenos Aires

CRU and Argus FMB are jointly convening Latin America's leading fertilizer conference at the Sheraton Hotel and Convention Center, Buenos Aires, Argentina, 25-27 January 2017.

The conference opens for morning registration on Wednesday 25 January, continues with a series of technical showcase presentations in the afternoon, followed by a welcome reception in the evening. The event formally starts the next day with two keynote addresses from Luis Maria Urriza, Subsecretary of Agriculture at Argentina's Agroindustry Ministry, and Charlotte Hebebrand, Director General of the International Fertilizer Association (IFA). Wide-ranging conference sessions then run throughout Thursday 26 January and Friday 27 January.

Topics covered include:

- CRU's N, P & K Market Outlook
- Argentina's future in fertilizers
- Micro-nutrients and speciality fertilizer
- Liquid and sulphur containing fertilizers
- The Brazilian market
- Investment in Latin America
- Regional markets
- Agrimineral

The conference closes on Friday afternoon with a thought-provoking workshop on crop quality, human health & the environment.

Fertilizer Latino Americano is the leading conference for those involved in fertilizer production and trade in the Latin American market. The three-day event regularly attracts over 650 delegates from more than 50 countries, and has long been the place to meet-up and conduct fertilizer business in the region. The conference provides an excellent opportunity to:

- Network with fellow professionals from across the globe
- Meet new customers in the fast-growing Argentinian market
- Hear the latest nitrogen, phosphate and potash market outlooks
- Understand future requirements for bulk and speciality products

Growing fertilizer demand has made Latin America an increasingly important destination for trade and investment. In recent times, the region has been a hotspot for investments and acquisitions in mines, production facilities and distribution assets, as companies have competed to secure market access and bolster their presence.

This year's conference takes place in Argentina, a country with a bright market outlook. Shortly after taking office last December, Mauricio Macri, the country's incoming president, abolished or cut taxes on grain and oilseeds. His removal of the so-called 'Dollar Clamp' also led to a 45% devaluation of the Argentine Peso. These reforms have increased agricultural sector profitability and boosted fertilizer demand (see feature opposite).

For those wishing to capitalise on fertilizer trade and business opportunities in Central and South America next year, Fertilizer Latino Americano 2017 in Buenos Aires this January is a must-attend event. *Fertilizer International* is pleased to be the official publication for this year's conference.

Right: Corn is one of Argentina's main agricultural exports.

Argentina is the second largest agricultural producer in South America with over 35 million hectares of arable land devoted to major crops such as corn, wheat and soybeans. Confidence in the country's agricultural sector is riding high following the recent introduction of sweeping policy reforms. These have prompted a strong recovery in fertilizer sales in 2016, with January-August purchases up 50% year-on-year.



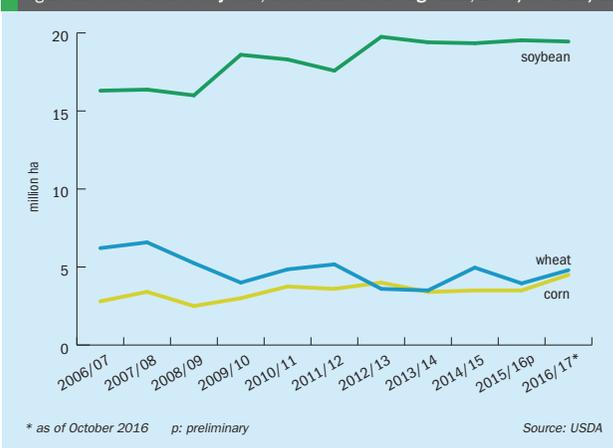
Argentina's rejuvenated fertilizer market

Argentina has one of the most productive agricultural economies in the world. Revenues from agriculture totalling \$66 billion contributed 6.5% to Argentina's GDP in 2014, rising to 12.6% of GDP once the downstream food processing is also included.

International sales of farm goods are also a major earner for the Argentinian economy. Agricultural exports worth \$43 billion made up 60% of the country's export earnings in 2014, including \$15 billion from the overseas sales of primary products. Export mainstays include soybeans, wheat and corn as well as processed products such as animal feed, flour and vegetable oils. Primary crops exports are mainly destined for China (23%), Europe (16%), the Middle East and North Africa (12%).

Argentina's abundant croplands produced 59 million tonnes of soybean, 27 million tonnes of maize and 11 million

Fig 1: Harvested area for soybean, wheat and corn in Argentina, 2006/07-2016/17



CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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Fig 2: Argentina's production and exports of soybean, wheat and corn, 2012-2017



Fig 3: Argentina's nutrient consumption, 2008-2015

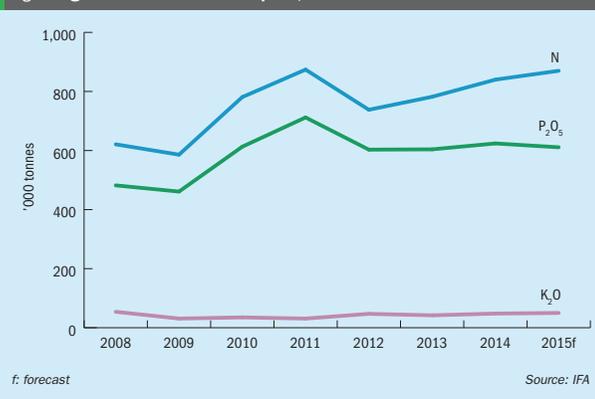
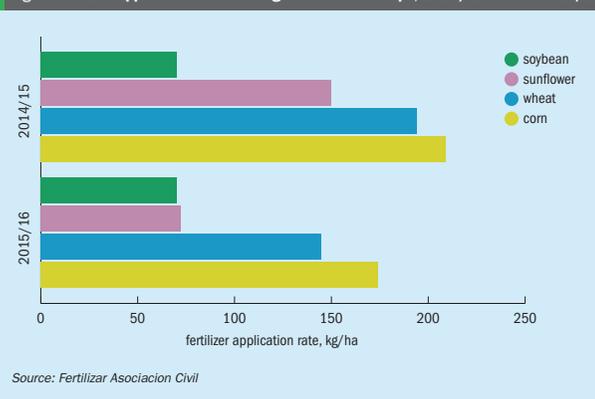


Fig 4: Fertilizer application rates for Argentina's main crops, 2014/15 versus 2015/16



tonnes of wheat in 2015/16. Argentina is the world's fourth largest biodiesel producer. This makes biofuels an important end-market for some of the country's crops. Around two-thirds of Argentina's bio-fuels output (3,900 million litres) is soy-based biodiesel production, with ethanol sourced from sugarcane and maize making up the remaining third.

Argentina has long been famous for its cattle ranching. Once the world's third largest beef exporter, Argentina fell back to 10th place in 2013, exporting some 236,390 million tonnes that year, placing it behind Brazil, Uruguay and Paraguay. Annual meat production is still a healthy five million tonnes, mostly beef (2.6 million tonnes) and chicken (2 million tonnes) supplemented by pork (400 thousand tonnes).

Argentina's productive dairy and viticulture industries also generate around 11,000 million litres of milk and 1,500 million litres of wine annually.

Growing popularity of soybean

The total area under cultivation in Argentina is around 39 million hectares. Wheat, barley, corn, soybean, sunflower and sorghum are all extensively grown¹.

The harvested area for wheat, Argentina's main winter crop, has declined from over six million hectares to below four million hectares over the last decade (Figure 1). The winter barley harvest area, in contrast, rose rapidly from less than half a million hectares to 1.7 million hectares between 2007/08 and 2012/13, although it has since fallen back again drastically. Corn, soybean and sunflower are Argentina's main summer crops. Soybean is an increasingly popular crop choice, with planting expanding from around 16.3 million to 19.5 million hectares between 2006/07 and 2015/16 (Figure 1).

Argentina is a major player in world cereal and oilseeds markets, exporting over four-fifths of its 56.8 million tonne soybean harvest and three quarters of its 28.0 million tonne corn harvest and 11.3 million tonne wheat harvest in 2015/16 (Figure 2). These trade volumes provide Argentina with a 13%, 8% and 3% share of the global export market for corn, soybean and wheat, respectively. Brazil's corn and soybean output has, however, outpaced Argentine production over the last decade and, as a result, Brazil's corn exports overtook those of Argentina in 2011/12.

Until recently, Argentina's grain and oilseed trade with the rest of the world was hampered by taxes and quotas on grain exports. These policies were designed to retain supplies in the country and keep domestic prices low. But, in reality, falls in the harvested area for wheat led to lower supplies and higher local wheat prices, the very opposite of what was intended.

High nitrogen and phosphate demand

Argentina's nutrient consumption, although overshadowed by Brazil's 13.2 million t/a level, is relatively large by regional standards, being three times greater than Chile's consumption, for example.

Argentina's fertilizer consumption used to be minimal, as the country's extensive rich soils did not require much fertilization. That all changed with a large expansion of grain production in the first half of the 1990s. This was accompanied by a five-fold increase in nutrient consumption from 165,000 tonnes in 1990 to 855,000 tonnes in 1996. Since then, Argentina's consumption of primary nutrients has increased by almost a third, growing from 1.16 to 1.53 million tonnes between 2008 and 2015 (Figure 3). Greater use of nitrogen and phosphate, up 40% to 870,000 t/a N and up 27% to 611,000 t/a P₂O₅, have been behind this rise. The country's low K usage (50,000 t/a K₂O), in contrast, has remained unchanged in recent years and now represents just 3% of overall nutrient use.

Fertilizers: indicators of agricultural health

Fertilizer applications in Argentina vary according to crop type and the area under cultivation. Fertilizer demand from soybean is relatively low compared to other commonly cultivated crops, making it less costly to grow. Fertilizers are only applied to 62% of the land area under soybean cultivation, for example, a percentage that rises to 83% for sunflower, 89% for wheat and as high as 91% in the case of corn². Application rates for wheat, corn and sunflower can also be more than double the 70 kg/ha typically applied to soybean (Figure 4).

Argentina's fertilizer market expanded dramatically between 1990 and 2011, mirroring rises in crop acreage and agricultural output, with fertilizer product deliveries growing from below 0.5 million t/a to above 3.5 million t/a over this period.

Although the output from domestic fertilizer production has made an increasing contribution to supply, the country continues to rely on imports for more than half of its fertilizer needs (Figure 5). Import demand over the last five years has been particularly strong for phosphate and nitrogen products such as MAP, DAP, TSP, UAN, Urea, CAN and AN. Argentina is also completely import-reliant for potash, as it lacks a domestic supply source currently.

Fertilizer imports are a reliable indicator of the health of Argentine agriculture in general, and the state of corn and wheat growing in particular. They last peaked at 2.4 million tonnes in 2011 but fell back to 1.2 million tonnes last year (Figure 5).

Fertilizer consumption in Argentina has stagnated in recent years and fell to its lowest level in over a decade in 2015. Less attractive farm economics meant that many Argentinian farmers cut their direct costs, including fertilizer inputs, to save money⁴.

On average, only 10% out of the 40% of farm revenues spent on agrichemicals in Argentina is typically allocated to fertilizers,

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

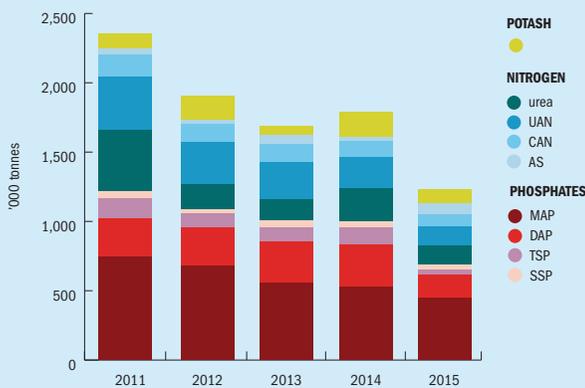
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FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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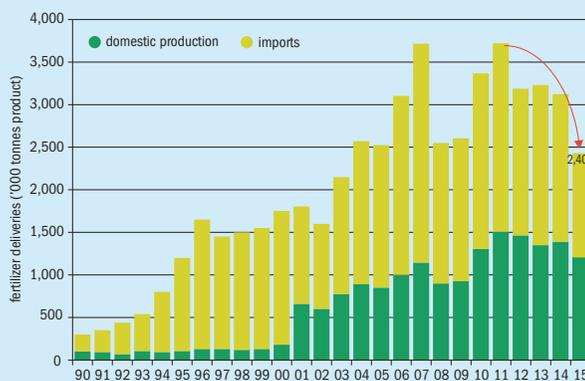
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Fig 5: Argentina's fertilizer imports, 2011-2015



Source: Ricardo Melgar, INTA

Fig 6: Argentina's fertilizer product consumption, 1990-2015



Source: Llambias (2016)

a percentage that was further reduced in 2015 as farmers tightened their belts². As a consequence, fertilizer product deliveries fell from over 3 million tonnes in 2014 to an estimated 2.4 million tonnes last year (Figure 6). The decrease in fertilizer use is clearly shown by the fall in applications rates in 2015/16 compared to the previous year (Figure 4).

The downturn in fertilizer consumption last year affected imports. Total UAN

imports of 185,101 tonnes were down 27% on 2014, for example. Total phosphate fertilizer imports also fell by more than a quarter to 725,000 tonnes in 2015. In terms of individual phosphate products, MAP imports dropped by a fifth to 461,000 tonnes whilst DAP imports were down a third to 201,000 million tonnes. TSP imports were just 63,000 tonnes in 2015, less than half the amount imported in 2014.

Profertil and Bunge rule the roost

Ownership of domestic fertilizer production in Argentina is divided between two major companies: Bunge, a manufacturer of single superphosphate (SSP), prilled urea and urea ammonium nitrate (UAN), and Profertil, a granular urea producer.

Profertil, a 50:50 joint venture between Agrium and state oil and gas company YPF, is a major nitrogen producer and distributor in Argentina. Its Bahía Blanca nitrogen complex has the capacity to produce 809,000 t/a of ammonia and 1,343,000 t/a of urea, following a recently-completed debottlenecking project.

Profertil's emergence as a local urea supplier has transformed Argentina's domestic fertilizer market. Around 45% of the fertilizers used in Argentina are nitrogen-based, and these needed to be imported before Profertil began production. Bahía Blanca now produces around 90% of Argentina's urea and 89% of its ammonia requirements, and even exported 15,000 tonnes of products in 2014².

Output from the Bahía Blanca plant has played a pivotal role in reducing fertilizer import dependency, as Miguel Morley, Agrium's managing director for South America, explains: "The domestic urea market in particular faced a significant production deficit. More than 90% of Argentina's total fertilizer consumption – more than 1.5 million tonnes – was imported, while urea demand was at around 600,000 tonnes."

Agrium set up the Profertil joint venture with YPF in 1998 and has been trading in Argentina under the name Agroservicios Pampeanos (ASP) since 1995. Its 50% stake in the Bahía Blanca plants provides its ASP retail outlet with around 700,000 tonnes of urea annually.

Profertil's main competition comes from US-headquartered **Bunge** who produce, blend and distribute a range of liquid and solid nitrogen fertilizers. Bunge integrates fertilizer production with its grain-buying business by distributing and selling fertilizers to its grain suppliers.

Bunge's in-house fertilizer range include three solid fertilizers, prilled urea, single superphosphate (*SP20 Ramallo*) and NPK mixtures (*Startmix*), and three liquid fertilizers, UAN (*SolMIX*), ammonium thiosulphate (ATS) + UAN (*SolMIX*) and potassium thiosulphate (*SolKS*).

Bunge's Campana nitrogen complex near Buenos Aires has the capacity to

produce 500,000 t/a of UAN, 135,000 t/a of ATS and 508 t/d of prilled urea. Campana is also capable of producing liquid potassium thiosulfate and NP+S fertilizers containing zinc and boron.

In November 2014, Terminal de Fertilizantes Argentinos, a joint venture between Bunge and the Asociacion de Cooperativas Argentinas (ACA) bought Mosaic's Quebracho complex at Puerto General San Martin for \$24 million. The purchase also provided Bunge with a 75% controlling interest in the SSP plant and river port at Ramallo in the Parana region.

Mosaic offloaded its Argentine assets two years ago, saying their profitability did not justify its investment. The company's outlay on its SSP plant in Argentina was reportedly based on an expectation that the domestic fertilizer market would eventually grow to five million t/a. But the shrinking growing area for wheat and corn, two crops with high fertilizer demand, plus import and currency complications, appear to have influenced Mosaic's decision to exit Argentina.

Even though Argentina's fertilizer market shrank to below 2.5 million tonnes in 2015, Jorge Bassi, Bunge's marketing manager, expects demand to recover to 4.5 million tonnes in the near future². Changes to agricultural tariffs and a new soil improvement law (see below) will greatly benefit fertilizer sales in Bassi's view: "We could see a complete turnaround in the Argentina agricultural model in the next two to three years as we encourage farmers to take care of the soil and adopt environmentally-friendly measures."

Agrium's distribution and retail business in Argentina, ASP, provides a sales channel for the granular urea produced at its Bahía Blanca joint venture with YPF. Bunge also collaborates with ACA on fertilizer distribution and the grain trade. These strategic partnerships are said to provide Bunge and Profertil with a 70% share of the fertilizer distribution market in Argentina, leaving Nidera and Yara with a share of around 10 % each.

More domestic competition could be on the cards after Argentine agrochemicals company **Rizobacter** announced plans to begin fertilizer production in 2016². "We are finishing a fertilizer plant for high-solubility, micro-granulated, phosphorous-based fertilizers in partnership with De Sangosse," said Ricardo Yapur, Rizobacter's president. The firm will be the exclusive producer of De Sangosse products in Argentina.

Vale also confirmed in April that it is reviving its Rio Colorado potash project in Mendoza province, Argentina. This was mothballed in 2013 after Vale had invested \$2.2 billion in the \$5.9 billion, four million tonne capacity mining venture.

Vale has drastically scaled-back the mine's investment requirements by cutting potash output to 1.3 million t/a and replacing plans for a 352 kilometre railway to the port of Bahía Blanca with truck transport instead. An upfront investment of \$1.5 billion will still be necessary however.

Vale acquired the Rio Colorado project from Rio Tinto in 2009. Start-up was originally scheduled for 2014.

Sweeping policy changes

Agricultural and food supply companies in Argentina made good profits during the period of high commodity prices. But price falls during 2014 and 2015, combined with domestic policies such as the export affidavit (ROE) and commodity export tax (retenciones a las exportaciones), did hit farm profits, particularly for wheat



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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino
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COVER FEATURE 2

Argentina's
fertilizer market

COVER FEATURE 3

Drip irrigation
review

COVER FEATURE 4

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and corn. Argentina's farmers reacted to this by reducing their spending on inputs and switching some of their production to lower-cost crops – soybean is 80% cheaper to grow than corn, for example. Falls in crop prices over the last few years have generally resulted in more soybean and less corn and sunflower growing in Argentina – and consequently less fertilizer buying too¹.

However, the end of 2015 saw the introduction of major changes in economic policy designed to boost agricultural production and crop exports. A radical set of changes were introduced by Argentina's new president, Mauricio Macri, within days of his taking office in December last year. Macri moved quickly, allowing the Argentine peso to float, abolishing wheat and corn export taxes and enacting a raft of other reforms. Measures included:

- Removal of foreign exchange restrictions
- Unification of official and parallel exchange rates
- Immediate devaluation of the Argentinean peso against the US dollar from ARS9.8/\$ to ARS13.3/\$ by allowing it to float on 17 December
- Abolition of the import affidavit (DJAI).
- Abolition of overseas payment restrictions limiting the purchase of imported agricultural inputs
- Abolition of the export affidavit (ROE)
- Abolition of the export tax (retenciones a las exportaciones) for selected commodities

Overall, the newly-introduced policy changes should make Argentina's agricultural exports much more competitive, improve returns for agricultural producers and make investing in wheat and corn more attractive. Export taxes on wheat and corn – of 23%, 20% and 15% respectively – were completely removed, whereas levies on soybean were maintained, albeit lowered from 35% to 30%. Consequently, an expansion in corn and wheat growing areas in 2016 and a corresponding improvement in fertilizer application rates are being forecast¹.

Fertilizer market rebounds

There are encouraging signs that Argentina's agricultural production and fertilizer market has started to rebound in 2016 in response to the removal of export duties on cereals and new measures supporting fertilizer imports.

Fertilizer purchases from January to end August this year were 1.53 million tonnes, up 50% on the 1.02 million tonnes purchased during the same period last year. Encouragingly, Argentina imported 110,739 tonnes of UAN in the first half of 2016, the highest figure for at least three years. Combined phosphate imports (DAP/ MAP/TSP) between January and August, at 799,175 tonnes, rose by 69% compared to the same period last year. DAP imports were up 66% year-on-year to 244,475 tonnes for the first eight months of 2016, while MAP imports increased 57% to 489,272 tonnes. Argentina imported 65,428 tonnes of TSP between January and August, an almost five-fold increase on the first eight months of 2015.

Much of the fertilizer purchased in Argentina during May and June will have been applied to the newly-planted winter wheat. Planting for this crop increased by 9% (360,000 hectares) to 4.30 million hectares in 2016/17. The latest forecast for Argentina's 2016/17 corn crop, which began planting in October, is for a 25% increase (800,000 hectares) to 4.30 million hectares. Because the two crops directly compete for land use in Argentina, increased corn planting is expected to reduce soybean acreage by 3% (600,000 hectares) to 19.40 million hectares in 2016/17.

Future promise

"Argentina's agricultural industry has experienced a rejuvenation in 2016," confirms Juan Cruz Jaime, executive director of trade body CropLife Latin America². "The elimination of export taxes on wheat and corn and a reduction in the taxes on soybean exports will impact positively on the agrichemical industry." He expects Argentina's agrichemical industry to grow by around 15% in 2016, with turnover for the full year reaching \$2.7 billion².

The current Argentine government has set itself the ambitious goal of increasing agricultural output from 100 million t/a to 160 million t/a by the end of its four-year term. The impact of removing taxes on wheat and corn could see output hit record highs by 2017, according to some in the industry.

"We can expect wheat acreage to grow by one million hectares to around 4.7 mil-

lion hectares. This will however still be lower than the six million hectares we have previously seen," comments Ulrik Ekonen, Latin America manager at Nufarm Argentina "Argentina's corn production will increase by around 700,000 hectares to 3.4 million hectares."

Fertilizer use in Argentina will also be boosted under a plan to offer tax breaks for farmers who use more fertilizers. Argentina's fertilizer association, Fertilizar,

Recent changes to export taxes will greatly benefit fertilizer sales.

is working with the government to introduce these buying incentives as part of a soil improvement law, as Jorge Bassi, Fertilizar's president, explains:

"Fertilizers are crucial for the industry in producing more wheat and corn, rather than relying on soybean crops. Ten years ago,

soybean planting was both very cheap and very easy, while the return on investment was high. This led to an over-reliance on soybean crops to the detriment of other crops, and nutrients were leached from the soil without being replaced".

This is what makes a soil improvement law necessary, in Bassi's view: "Rules have to be made... to ensure the quality of the soil for the future. In the future, we will also have rules for the correct usage of agrichemicals."

Argentina's future as a strong and expanding market for crop inputs is certainly looking more assured as a result of recent reforms. The country's crop protection and seed product sales totalled \$3.5 billion in 2014, according to Agrium. The Canada-based fertilizer producer and farm retailer is also forecasting 5% annual growth in nitrogen, phosphate and potash consumption in Argentina between 2016 and 2020.

Acknowledgement

Dr Ricardo Melgar of INTA is thanked for his contribution to this article.

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Getting more crop per drop

The development of drip irrigation is arguably one of the most important agricultural advances of the last 50 years. Although more than 11 million hectares of land are watered by drip irrigation globally, the technology's agricultural potential is still in its infancy. The thriving commercial market for drip irrigation equipment is worth \$2.2 billion and expanding by around a fifth every year. Fertigation – the ability to efficiently manage and regulate both water and plant nutrients – is a key advantage that is helping drive worldwide growth.

In June 2012, David Hillel, an Israeli scientist who pioneered an innovative way of efficiently delivering water to crops in arid and semi-arid regions, was awarded the World Food Prize. The method Hillel helped develop, drip irrigation, supplies water directly to plant roots in small amounts – dramatically cutting crop water requirements and at the same time boosting crop yields.

Rising population, falling water availability

Competing demands on the world's water means that Hillel's innovation is much needed. Whilst humans usually consume a couple of litres of water each day for drinking purposes, a further 3,000 litres is typically needed to sustain a person's daily food needs. Agriculture also uses 70% of the water withdrawn from the world's aquifers, rivers and lakes, placing pressure on the planet's limited freshwater resources. Groundwater is also under pressure as more than two-fifths of the water used for irrigation globally is extracted from aquifers.

Irrigation has become an increasingly common agronomic practice in recent decades. Indeed, the agricultural land area dedicated to irrigation has more than doubled since the 1960s, according to UN figures, growing from 139 million hectares in 1961 to 301 million hectares by 2009.

Crop growing on irrigated land is much more productive than conventional rain-fed agriculture, generating two-fifths of global food production from a fifth of the world's total cultivated area. Unsurprisingly, irrigation, because of its greater productivity and water efficiency, looks set to play an increasing role in feeding a growing population and ensuring food security, especially at a time when the volume of water available for agriculture is expected to diminish. A global water deficit of 40% is expected to emerge by 2030, analysts at Rabobank warned recently, unless water management improves.

Most farmers still irrigate their fields by flooding or watering the furrows between crop rows. Unfortunately, less than half the irrigation water applied to fields in this way actually benefits crops. The excess water is not necessarily lost, as some of it will return to rivers or groundwater sources to be used again. However, the overuse of water for irrigation purposes can deplete freshwater supplies, result in large evaporation losses and elevate pesticide and salt levels in surface runoff.

Drip irrigation

The drip irrigation system invented in Israel by Simcha Blass and his son Yeshayahu in 1959 is one of the most significant advances in modern agriculture. Due to

its water- and fertilizer-saving abilities, drip irrigation – also known as micro-irrigation, trickle irrigation or localised irrigation – has since become an increasingly common method for growing crops in greenhouses and fields.

In drip irrigation, drops of water are supplied at (or below) the surface, close to plants at very low rates (2-20 litres/hour) via a pressurised system of small diameter plastic pipes. These are connected to outlets called emitters or drippers. Enough water is applied at regular intervals, usually every 1-3 days, to wet the root zone and provide the high moisture conditions plants need to flourish.

Drip irrigation is more efficient than other methods which saturate the whole soil profile, such as surface and sprinkler irrigation. This reduces weed growth and the leaching of plant nutrients. The drip irrigation of 100-200 plants typically consumes 40-80 litres per day. In arid and semi-arid regions, drip systems often use recycled wastewater, particularly in Israel and around the Mediterranean.

Drip irrigation systems are suitable for crops grown in rows, including vines, vegetables and fruit trees, with one or more emitters allocated to each plant. Installation is generally only economic for high-value crops due to the capital costs involved.

A typical drip irrigation system (Figure 2) is made up of the following components:

- **Pump unit:** this delivers water from the source to the pipe system under pressure.
- **Control head:** this uses valves to control the system's flow rate and pressure and may also contain screen filters and sand filters to remove finely-suspended matter. Some control head units are fitted with a nutrient tank for fertigation. This allows fertilizers to be added to water in measured doses – one of the major advantages of drip irrigation.
- **Mainlines, submain lines and laterals:** these pipes distribute water from the control head to the field. They are usually made from PVC or polyethylene hose and are often buried to prevent degradation from the sun. Lateral pipes are usually 13-32 mm in diameter.
- **Emitters (drippers):** These devices control the release of water to plants. They are usually spaced along laterals at more than a metre apart, with one or more emitters used for a single plant such as a tree, although they are generally more

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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Fertilizers, fertigation and water use efficiency

Water and nutrient use can be managed and regulated in tandem using fertigation – the application of liquid fertilizers via a drip irrigation system. Valuably, fertigation provides nutrients to crops in the right amounts at the times they are most required, and at locations where they can be taken-up most effectively by roots. Supplying soluble nutrients continuously and directly to the root zone of plants through fertigation has multiple benefits, as it minimises fertilizer over-application, nutrient leakage and groundwater pollution as well as maximising economic yield¹.

Water and fertilizers are often the two most important controls on crop yield and quality, particularly in an arid or semi-arid climate. In the Canadian prairie, for example, water is the most limiting crop production factor and nitrogen the second most limiting. Indeed, the water and nutrient requirements of crops, and their efficient use, are entwined issues. Poor soil fertility, for example, limits the ability of plants to use water efficiently because of poor root growth².

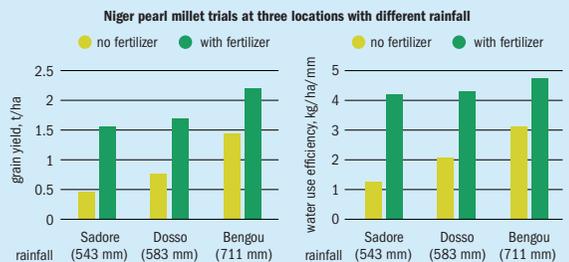
Water use efficiency (WUE) monitors the effectiveness of water use in crop production by measuring the yield produced per unit of water consumption. It is often expressed as the ratio of crop yield to evapotranspiration – the net transfer of water from the field to the atmosphere by both soil evaporation and plant transpiration. WUE can be increased using a range of water conservation measures, including evaporation suppression, weed control and irrigation scheduling².

Nutrients supplied by fertilizers have an influence on WUE by affecting the duration, growth rate and senescence (aging) of plant leaves. Nitrogen and phosphorus deficiencies usually result in smaller leaves, for example. The application of nitrogen typically increases transpiration by promoting new leaf growth and delaying senescence².

An adequately fertilised soil will generally cause higher transpiration, by boosting root and shoot growth, yet reduce overall evapotranspiration by promoting rapid ground cover. Crop trials have examined how water and fertilizer use interact. As the following trial results suggest, fertilizer availability improves water use efficiency and, correspondingly, water availability generally improves fertilizer use efficiency²:

- NPK applications increased the yield (t/ha) and WUE (kg/ha/mm) of pearl millet in trials at three locations with differing rainfall in Niger (Figure 1)
- Combining irrigation with fertilizer (N+P) applications increased root biomass, leaf area index and shoot biomass in spring wheat in China's semi-arid Loess plateau
- In a trial at Ludhiana, India, nitrogen improved the capacity of wheat to extract water and caused higher transpiration by increasing the depth and density of roots and the leaf area index
- Better water supply also improved fertilizer use efficiency by increasing nutrient availability in the Ludhiana wheat trial

Fig 1: Yield and water use efficiency with and without NPK fertilizer application



Source: Roberts (2016)

closely spaced when used for row crops. Emitters should discharge at a constant flow, even when the pressure varies, and are designed not to block easily.

Drip irrigation systems require regular upkeep to maintain their efficiency. Leaks may develop due to pipe damage, for example, and emitters can also become blocked, even with filtered water. The build-up of salinity also needs to be monitored carefully, as salt can accumulate in soil along edge of the wetting front. Extra irrigation may also be necessary during crop establishment as wetting from drip systems may not be enough to trigger seed germination.

On sloping land, drip irrigation laterals are generally placed in parallel with crop rows planted along contour lines. This minimises any potential variation in emitter discharge due to land elevation. Water needs to be applied slowly during the drip irrigation of clay soils to avoid ponding and runoff. Higher emitter discharges are used on sandy soils to ensure wetting is sufficient.

Because drip irrigation saturates a relatively small volume of soil, plants develop their roots in a small localised zone nearest to the water emitter. This limited root system is not problematic as long as favourable soil conditions are maintained. Roots require soils with low salinity, adequate aeration and suitable chemical and physical conditions.

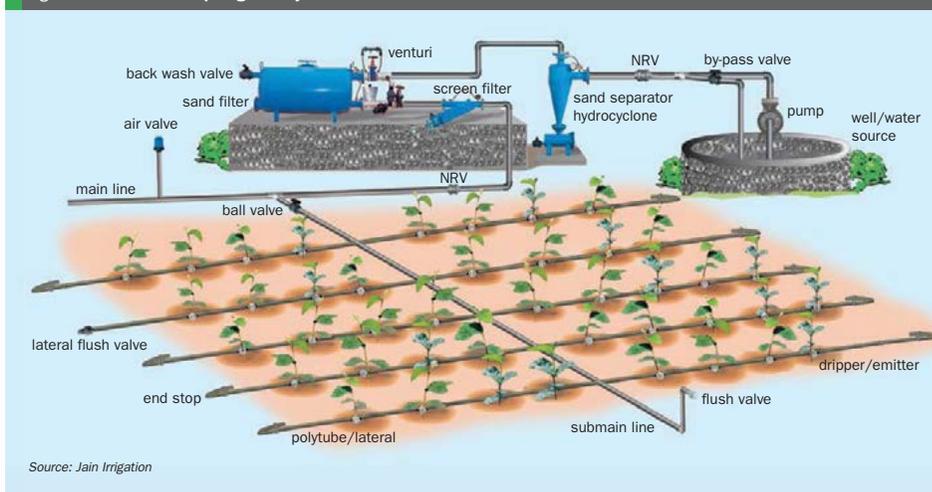
A growing presence

Drip irrigation was adopted on a large-scale during the 1970s for fruit and vegetable production in Australia, Israel, Mexico, New Zealand, South Africa and the US. Compared to conventional flood or furrow irrigation, drip irrigation has the potential to reduce water use by up to 70% and at the same time increase crop yields by 20-90%.

The global area covered by drip irrigation systems has more than tripled over the last twenty years, rising from 2.98 million hectares in 1996 to 11.1 million hectares currently (Figure 3), based on the latest figures published by the International Commission on Irrigation and Drainage (ICID).

The most dramatic expansions have occurred in the world's top two irrigators, China and India, where the area under micro-irrigation has grown 88-fold and 111-fold, respectively, over the last two decades. Four countries globally, India, Spain, China and the US, each have in excess of 1.5 mil-

Fig 2: Schematic of a drip irrigation system



Source: Jain Irrigation

lion hectares devoted to cultivation by drip irrigation. California, due to the concentration of fruit and vegetable growing within the state, accounts for 62% of the area under micro-irrigation in the US, with Florida and Texas coming a distant second and third.

The switch from traditional irrigation methods to drip irrigation makes most economic sense for high-value crops grown in water-scarce regions. The resulting water savings can be considerable. In northwest China, for example, furrow or flood irrigation methods have an annual water demand of 7,320 m³/ha on average, compared to only 3,250 m³/ha for micro irrigation¹.

Drip irrigation is used without fertigation in most developing countries, with fertilizer dressings being applied by broadcasting and banding instead. In other countries, particularly Israel, the integration of fertigation has been a key factor behind drip irrigation's rapid adoption. The simultaneous delivery of water and nutrients directly to the root zone is known to be advantageous (see box) for a number of crops – tomatoes and other salad vegetables, for example – and also helps minimise nitrate-leaching losses¹.

Drip irrigation has been rolled-out to cover three-quarters of the total land under irrigation in Israel. Its success there is undoubtedly linked to the fact that the method was originally pioneered in Israel, and because of other factors such as limited water availability.

Key benefits and sub-surface irrigation

Drip irrigation is water efficient because it wets the soil sufficiently to satisfy the transpiration demands of plants, yet keeps soil evaporation losses and the deep percolation of water to a minimum. Application efficiencies as high as 0.9 are possible with drip irrigation, compared to 0.6-0.8 for sprinkler systems and 0.5-0.6 for surface irrigation¹.

Switching from flood irrigation to drip irrigation – by enabling crops to be grown on sloping land that was impossible to water previously – has also enabled irrigated land area to double in some regions. Sugarcane cultivation in Maharashtra, India, is one notable example¹.

Another advantage of drip irrigation is its ability to balance soil aeration with wetting, whereas soils become waterlogged at times during furrow and flood irrigation, so reducing the supply of oxygen to roots. Valuable plant nutrients are also partially removed as excess water drains from the soil.

Installing the drip system beneath the soil surface further reduces soil evaporation and delivers water and nutrients directly to the root zone. In the Middle East, the switch from furrow irrigation to sub-surface irrigation has doubled wheat yields in some instances¹. Similar yield and water use efficiency improvements have been reported for tomato, cotton, alfalfa, and cantaloupe.

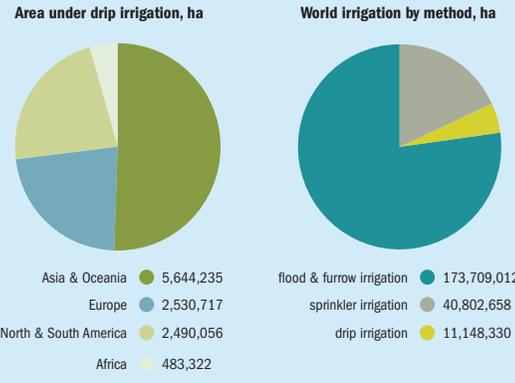
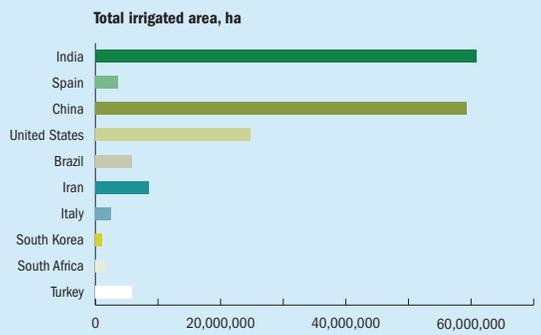
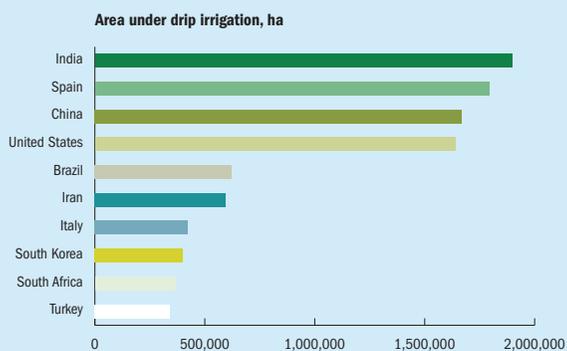
Much higher water use efficiencies are also obtained in sub-surface irrigation (1.64-3.34 kg grain/m³) than is possible with furrow irrigation (0.46-1.2 kg grain/m³). Soil nitrogen release is also much higher under subsoil irrigation (11-216 kg/ha) compared to furrow irrigation (11 to 33 kg/ha).

Markets and companies

The global market for commercial drip irrigation systems was valued at around \$2.2 billion last year. The market is currently growing at 17-18% per annum and could be worth as much as \$5.6 billion by the end of the decade, according to some estimates. The US is currently the world's largest market for micro-irrigation systems. Looking ahead, however, the Asia-Pacific region – India and China in particular – is thought to have the strongest growth potential over the next four to five years (19-20% p.a.).

Four major players, Netafim Limited (Israel), The Toro Company (US), Jain Irrigation Systems Ltd. (India), and Rain Bird Corporation (US), collectively control more than half of the global market for drip irrigation systems. Five other companies, EPC Industries Limited (India), Nelson Irrigation Corporation (US), Rivulis Irrigation (Israel), Valmont Industries, Inc. (US), and T-L Irrigation Co. (US), also have a major presence in the market.

Fig 3: Land area under drip irrigation, 2015



Note: Some country estimates date back to 2004. Source: ICID Annual Report, 2015/16

50 years in the business

Netafim, the global market leader in drip irrigation, celebrated its 50th anniversary last year. The firm has 28 subsidiaries, operates 16 manufacturing plants and has more than 4,000 employees worldwide, enabling it to deliver systems and components to some two million customers in 110 countries.

In 2014, its Indian subsidiary won a \$62 million contract with state-owned Krishna Bhagya Jala Nigam Ltd for reportedly the world's largest micro-irrigation project in the southern state of Karnataka. This will see Netafim build an automated drip irrigation network covering 11,800 hectares of land cultivated by around 6,000 farmers in the Bagalkot area of Karnataka.

Last year, Netafim also signed a \$17 million agreement with Vingroup, a large Vietnamese real estate operator, for one of Southeast Asia's largest greenhouse projects. The deal involves supplying greenhouses, drip irrigation and climate control systems.

Netafim has expanded the use of drip irrigation for cotton cultivation globally, notably in Australia, Egypt, Israel and the US. The installation of a Netafim sub-surface drip systems in the Philippines has also increased sugar cane yields by 90% compared with a conventional centre-pivot sprinkler system, and cut water consumption by 70% – a huge increase in water productivity. The sucrose content of the sugarcane crop was also boosted by 5%, according to Netafim.

Netafim recently launched *Aries*, a low-flow irrigation dripper designed to boost yields under harsh water conditions. Netafim CEO, Ran Maidan, explained their benefits: "Our next-generation low-flow drippers are part of the global effort to fight food scarcity. By improving crop yields regardless of water quality, while lowering dependence on water and other resources, the new line is helping us revolutionize irrigation." Netafim's new *Orion* dripper design has also improved the clogging resistance, durability and operational efficiency of its micro-irrigation systems.

Indian champion

Jain Irrigation Systems Limited is India's largest and the world's second largest micro-irrigation company. The company manufactures drip irrigation systems and components at a plant at Jalgaon. These are purchased by farmers growing apples,

grapes, banana, sugarcane, tea, coffee, cotton, mango, teakwood, vegetables and flowers. Drip irrigation typically cuts water use by 70% compared to flood irrigation – allowing more land to be irrigated – and also increases fertilizer use efficiency by 30%, according to Jain. The company expanded twenty-fold between 2003 and 2010, and is continuing to grow strongly with domestic micro-irrigation sales increasing by more than 17% last year.

Rice is a notoriously water-hungry crop. So it is unsurprisingly that Jain is targeting the 43.8 million hectares under cultivation in India. Almost 85% of fresh water consumption in India is for agriculture, much of which, some 70%, is used in paddy cultivation.

Trial results have been encouraging. Drip-irrigated fields in Tamil Nadu consumed a third of the water to yield 22% more rice per hectare, in comparison to conventional paddy growing. The switch from paddy growing to drip irrigation by a commercial rice grower in Rajasthan increased crop yield by 25% and reduced water and electricity consumption by 40% each. The water saved enabled this farmer

to expand the area of rice under cultivation from 2.8 to 4.8 hectares.

Jain strengthened its presence in the US market last year by buying PureSense Environmental Inc, a Californian irrigation management and field monitoring technology company.

Jain has also championed solar powered drip irrigation systems for off-grid farming. It has been working with Harvard University on a solar irrigation project for village rice farmers in Bihar since 2013. In September, the firm won a €18.7 million government contract to supply and install solar photovoltaic drip systems at 14 different locations in Eritrea. The project will take 18 months to complete and should benefit 2,000 small-scale African farmers.

Untapped potential

Drip irrigation's agricultural potential, and its use as a vehicle for fertigation, is still in its infancy, as Rabobank makes clear: "Only 40-45% of existing irrigation systems possess water-saving technologies... such as micro-irrigation... Water-saving irrigation systems can also help improve the

efficiency of fertilizers and agrochemicals."

Although the majority of irrigated crops are watered by other methods (Figure 3), the use of drip irrigation will continue to grow on farms where the water supply is costly or limited due to low rainfall, drought or other reasons. Its adoption can also be economic in situations where farmers have to compete with urban users for the supply of water. But only if the improvements in crop yield and quality delivered by drip irrigation are able to offset the additional costs involved.

Conserving water and reducing labour costs have been the main motivations for switching to drip irrigation in the past. But the economic gains from better crop yields and quality – and more efficient fertilizer use – look like becoming increasingly important deciding factors in future.

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

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Difference from average temperature (°F)

High sea temperatures (red) in the central Pacific, late 2015.

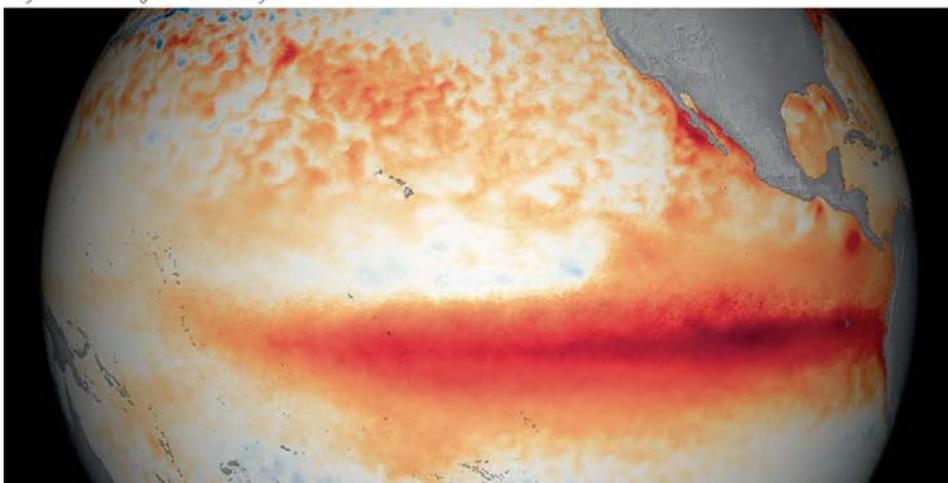


PHOTO: NOAA

'Godzilla' El Niño leaves a lasting legacy

We review the impact of the 2015/16 El Niño on global agriculture and fertilizer demand, and assess how climate change is influencing this irregular weather phenomenon. Maize harvests in South Africa and Central America, wheat production in Morocco, Malaysian palm oil output, and rice growing in India and Thailand were all hit by the latest El Niño event.

The El Niño episode which began in May 2015 and lasted until the following spring was either the most or the third most intense on record, depending on how it was measured. Such was its strength, some media outlets began calling it the 'Godzilla' El Niño due to its unprecedented magnitude.

El Niño – *The Boy* in Spanish – is associated with a band of warm ocean water that develops near the equator in the central and eastern Pacific. The converse phenomenon La Niña – *The Girl* – is caused by the cooling of ocean water in the same region.

Based on sea surface temperatures, the latest El Niño narrowly edged out the previ-

ous record-holder, the 1997/98 event. In the central zone of the Pacific, where scientists detect a developing El Niño or La Niña, sea temperatures peaked in November 2015 at 3.1°C above average, surpassing the previous 2.8°C record set in November 1997.

An El Niño develops when the westward trade winds in the Pacific weaken, allowing warm water to spread eastwards towards South America (photo above), bringing with it high rainfall. The event typically triggers drought across large swathes of Asia and Australia, whilst the Americas typically experience excess rain and flooding. El Niño's effects are also felt further afield, particularly in Africa.

El Niño, although often called abnormal, is a fairly frequent if irregular weather phenomenon. Episodes occur every two-to-seven years and last between nine months and two years. Some 31 El Niño events have been recorded since 1900.

What has certainly been abnormal about recent El Niño events is their size and severity. The floods, droughts, fires, storms and mudslides triggered by the 1997/1998 El Niño killed around 20,000 people across the globe and caused damage costing almost \$97 billion. The 2015/16 event has also been blamed for a number of costly and life-threatening extreme weather events across the globe.

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino
Americano,
Buenos Aires

COVER FEATURE 2

Argentina's
fertilizer market

COVER FEATURE 3

Drip irrigation
review

COVER FEATURE 4

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Drought, fire and flood

In a typical El Niño event, dryness develops over the Pacific and pushes north and west from Australia through Indonesia and into India during the middle of the year. Central America also becomes unusually dry around this time. Weather impacts tend to peak later in the year, during a three month period from December through to February, as El Niño reaches its maximum strength.

Last year's El Niño carried many of these hallmarks. It was blamed for India's weak monsoon last year, for example, and the country's summer heatwave that led to more than 1,100 deaths. It was also implicated in South Asian floods last winter. Five weeks of torrential monsoon rainfall blighted southern India and Sri Lanka, killing nearly 400 people and causing damage costing \$4 billion. "Southern India is having a lot of rain as it goes into winter, having come out of the dry monsoon. This is only so during extreme El Niño, so it is a confirmation that the El Niño is huge," commented Wenju Cai of Australian science body CSIRO last year.

In contrast, rainfall in Australia during September and October 2015 was the third lowest on record, although this dry spell ended before the year was over. October 2015 was also Australia's hottest ever month.

Drought and fires in Indonesia in the latter part of 2015 cost \$16.1 billion in damage (1.8% of GDP), according to some estimates, exceeding the \$9.3 billion worth of fire damage in 1997/98. The UN Food and Agriculture Organisation (FAO) also reported a 60% fall in the maize harvest in El Salvador, Guatemala, Honduras and Nicaragua during late 2015, blaming this on an El Niño-related drought across Central America.

Jeff Knight of the UK's Meteorological Office, whilst cautious about blaming El Niño for all of 2015's extreme weather, concludes that El Niño and climate change were contributory factors. "Global warming is a background tide that is rising, and we get all these features like El Niño on top of it," he said.

Bad for maize, rice and wheat

So what does an El Niño year mean for world agriculture? The impact of the phenomenon on maize, rice, soybean and wheat, the four largest global food crops, was assessed in a recent paper in *Nature*

*Communications*¹. These crops provide nearly 60% of agricultural food value, and are also responsible for a major share of world fertilizer demand.

Looking back at past El Niño episodes, the effects on crop production appear to be mixed, if damaging overall. Whilst El Niño typically pushes up average soybean yields by 2.1-5.4% globally, its influence on maize, rice and wheat yields is usually negative, depressing global yields by as much as 4.3%. Worldwide average yields of all four crops also tend to fall by as much as 4.5% during subsequent La Niña years.

Out of the four largest food crops, maize tends to be the worst affected by El Niño. Yields in North America, Southern Africa and East Asia all suffer slight-to-severe impacts, with any positive impacts confined to Brazil and Australia.

North American and Australian wheat production are often affected by El Niño due to abnormally warm and dry weather, respectively. Warmer and drier conditions in Asia also tend to depress rice yields in countries such as Thailand, Vietnam, India and south China.

Soybean yields tend to be higher in El Niño years because of favourable effects in Brazil and the US, the two main global producers, as both countries tend to receive anomalously high rainfall. Indian soybean production, in contrast, may be negatively affected due to higher temperatures and lower rainfall there.

Commodity markets keep a close watch

El Niño is closely watched on grain and oilseed markets because of its potentially detrimental effect on crop production and the price fluctuations this may cause. Any major change in crop production – resulting from drought in Australia and Southeast Asia or excess rain in parts of the Americas – will also have significant knock-on effects for fertilizer demand.

India, the second largest global market for fertilizers, is particularly sensitive to El Niño. In August last year, for example, analysts CRU reported that India MOP sales were being hit by El Niño dryness. Retailers in Southern India, where sales are concentrated, were struggling to sell product due to reduced monsoon rains. "[Indian] domestic demand could see a drastic slowdown, building inventories and halting import demand," warned CRU's Chris Lawson. "Potash is the most

sensitive of these fertilizers, with retailers in the main southern consuming states noting slow sales despite heavily discounted prices."

There were signs that El Niño was also starting to hurt business across Southeast Asia, a key growth market for fertilizers, particularly for phosphate and potash. By August 2015, CRU was reporting a drop in fertilizer sales of up to 40% in some Southeast Asian countries due to restricted rice planting and falling palm oil output linked to the lack of rainfall.

CRU also noted the potential upside to the 2015/16 El Niño. "Price advances from drought-induced supply shocks can help to boost fertilizer demand globally," commented Chris Lawson. "However, grain and oilseed inventories are currently very high and any supply shocks are likely to be absorbed by these ample availabilities, capping any price spikes."

The World Bank predicted that the agriculture market fallout from the 2015/16 El Niño, although the strongest on record, would be mainly regional. "El Niño... could reduce yields in grains (especially rice) and edible oils (palm oil). However, this risk is regional – in Asian countries including Indonesia, Malaysia and Thailand – rather than global," the bank forecast at the end of 2015.

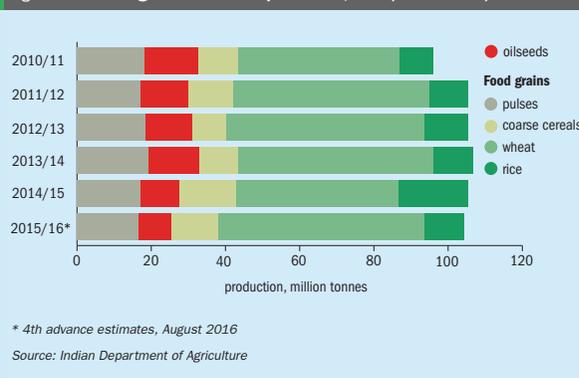
El Niño reaches its peak

El Niño peaked towards the end of 2015. The South African growing season got off to a particularly dry start, with the country in the grips of its second year of drought. Drier than average conditions were also reported in Thailand, Vietnam, the Philippines and Indonesia. Southern Brazil and northeast Argentina also experienced a wet beginning to their growing season.

The 2015/16 El Niño had a limited impact on Australian and North American agriculture though. Rainfall in Australia, below average in September-October 2015, subsequently recovered during the early part of 2016. Rainfall in the US southeast was also above average during December 2015. Winter storms also brought welcome rain to northern California. Rainfall in the state was 9% above average between October 2015 and March 2016, although large parts of California still remain in drought currently.

The 2015/16 El Niño eventually waned in May this year. This allowed meteorologists to take stock and look back at its main consequences, including:

Fig 1: Indian food grain and oilseed production, 2010/11 to 2015/16



- Floods affecting South America (Peru, north Chile, Bolivia, Paraguay south Brazil), the southern US and north Mexico.
- Poor monsoon rains in India
- Severe droughts affecting Africa (Morocco, Ethiopia and southern Africa) and South America (north and east Brazil, Colombia and Venezuela)

African and Latin American cereals hit

World cereal production was 2,525 million tonnes in 2015, based on recent FAO estimates. This is some 35.8 million tonnes (1.4%) below 2014's record production levels. Lower maize and rice harvests were the main causes of the fall.

African agriculture was particularly badly affected by El Niño-related dryness last year. Maize production in South Africa,

for example, contracted by one-third to 10.5 million tonnes in 2015, as the country struggled with its worst drought since 1904. This year's harvest is expected to fall further to 7.2 million tonnes.

After a strong cereals crop in 2015, Morocco also fell victim to drought this year, harvesting one of its smallest crops on record in 2016. The country produced just 2.7 million tonnes of wheat and 600,000 tonnes of barley compared to 8 and 3.5 million tonnes, respectively, in 2015 – a 70% collapse in Moroccan cereal production.

Widespread drought, even when it ends, will continue to affect African fertilizer demand this year and possibly beyond, according to the International Fertilizer Association (IFA), as buying power for fertilizers and other inputs will remain limited². Maize farmers in South Africa have

been struggling with debt levels because of drought and poor harvests.

The 2015 cereal growing season in El Salvador, Guatemala, Honduras and Nicaragua was also severely hit by prolonged dry weather associated with El Niño. The UN FAO reported a 60% fall in maize harvest and an 80% fall in the bean harvest in parts of Central America last year. The region's 2015 maize harvest, an estimated 3 million tonnes, was down 8% overall on 2014.

Brazil, in contrast, had a bumper harvest and was largely unaffected by El Niño last year. In fact, cereal output was a record 107 million tonnes, 6% up on 2014. However, by the end of 2015, El Niño finally made itself felt in Brazil – and looks like damaging this year's maize harvest. In the maize-producing states of Parana, Sao Paulo and Mato Grosso, severe dry weather was reported to have delayed planting of 2016 first season maize and reduced the growing area by 7%.

Asian rice production hit

The global rice harvest fell by 3.4 million tonnes to 491.4 million tonnes in 2015, largely due to adverse El Niño conditions. The fall is highly significant as it throws into reverse the sharp upward trend of the past decade. Indeed, global rice production has risen by seven million tonnes each year on average since 2006. Last year was the second successive year of below-trend rice production.

The drop in rice production was particularly acute in Asia, where the estimated harvest of 444.7 million tonnes is about 2 million tonnes below 2014. Thailand, India and the Philippines saw the sharpest



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What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

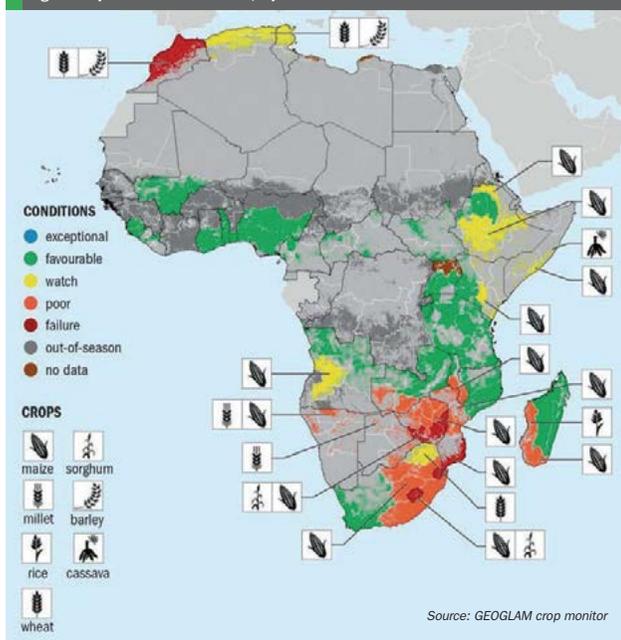
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ISSUE 475
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Fig 2: Crop conditions in Africa, April 2016



Fertilizer demand contracts

World fertilizer demand fell by 1.0% in 2015/16 to 181.2 million tonnes nutrients, according to IFA estimates released in May². Nitrogen and phosphate both fell by 1%, to 108.1 million tonnes and 40.9 million tonnes, respectively, whereas potash contracted by 0.8% to 32.2 million tonnes.

IFA linked the drop in demand for fertilizers to factors such as the economic slowdown in emerging economies and lower agricultural commodity prices. But IFA also explicitly cited “dry conditions across South Asia, Southeast Asia, Latin America and Africa owing to an exceptionally strong El Niño event” as being partly to blame for the fall in fertilizer demand last year.

Importantly, El Niño conditions prevailed in Latin America, Africa and South Asia, the three regions where 2015/16 fertilizer demand is thought to have declined most sharply. The steep demand fall in Latin America (-5.4%) reflected unfavourable economic, political and weather conditions in Brazil and Argentina. This percentage drop is equivalent to a 1.2 million tonne fall in primary nutrient consumption in the region.

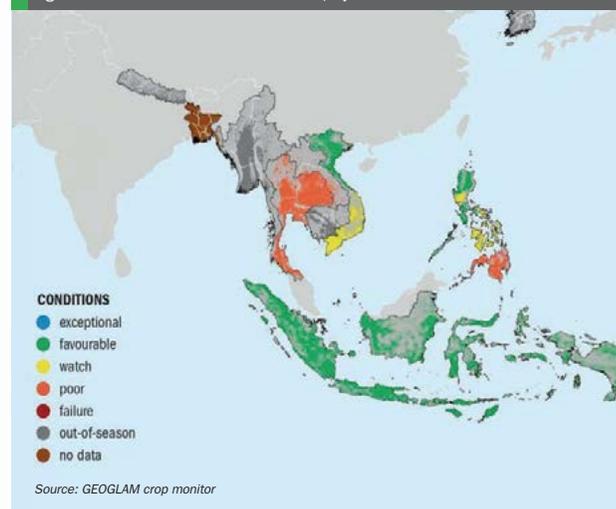
The 4.2% contraction in Africa demand was also attributed to the widespread drought there, as well as low commodity prices. The poor monsoon in India was again singled out by IFA as being partly responsible for a 1.9% fertilizer demand drop in South Asia. The 0.2% decline in East Asian demand was also linked to the impact of El Niño over large parts of Southeast Asia.

Hangover in Brazil, respite for India

Although the 2015/16 El Niño ended during May, as sea temperatures in the Pacific returned to normal, it still disrupted agriculture in many countries during the first part of this year. Crop conditions in Africa and Southeast Asia at the end of April 2016 are shown in Figures 2 and 3, respectively.

In Argentina, part of the summer maize and soybean harvest was lost due to flooding caused by heavy April rain. The absence of rain in late winter and spring also devastated Morocco's cereal harvest. In South and Southeast Asia, an exceptional April heatwave made routine agricultural work difficult in India. The start of summer rice planting in Bangladesh, Sri Lanka and parts of India was also disrupted by heavy rainfalls and flooding. Dry soils also jeopardised spring crop sowing in the Philippines³.

Fig 3: Rice conditions in Southeast Asia, April 2016



El Niño also had one final sting in its tail for world agriculture's powerhouse, Brazil. Cereal production there for 2016 (86.9 million tonnes) is expected to be the lowest since 2011, according to the latest FAO forecast. Early estimates for Brazil's second season (safrinha) corn crop suggest a 24% decline in maize output and a 27% yield drop, compared to the same season last year, due to severe dry weather associated with El Niño. A total maize harvest of 67.9 million tonnes is now expected for 2016. Brazil's wheat harvest, in contrast, is forecast to increase by 16% this year due to favourable crop conditions.

Unlike El Niño's continuing legacy in Latin America, there was relief and respite for Asian agriculture over the summer. India's monsoon rains returned to normal this year, with June-September rainfall for the country being restored to 97% of the long-term average. The FAO is expecting Indian cereal production to rebound in 2016 because of this. This will be welcome news for the nation's economy after the production shortfalls for rice, corn, sugarcane and oilseed crops last year. Agriculture accounts for almost one-fifth of India's \$2 trillion GDP and employs around half of its 1.3 billion population.

High wet season rains in 2016 also ended Thailand's two-year drought. A major recovery in rice production in Thailand, the world's largest exporter, is now expected this year. USDA is currently forecasting rice production of 18.6 million tonnes for 2016/17, up almost one-fifth on last year.

El Niño getting stronger

Looking ahead, the fertilizer industry may have to accept greater weather-related volatility in global fertilizer demand, as the 'Godzilla' El Niño events of 2015/16 and 1997/98 become more common in future.

Research suggests that El Niño episodes in recent decades have been the strongest of any period over the past four centuries⁵. The frequency of extreme El Niño events also looks set to double this century as a result of climate change⁶. Droughts and floods during El Niño years, and the resulting agricultural disruption, are likely to become worse because of this. La Niña events are also expected to become twice as common this century due to climate change. ■

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drops in output. The persistence of severe drought in Laos, the Philippines and Thailand hit rice growing particularly hard. In Vietnam, water levels in the lower Mekong River at the end of 2015 were at their lowest level in nearly 100 years ago, putting half a million hectares of fertile land at risk of saltwater intrusion².

India's June-September 2015 monsoon rains were also down 14% on the long term average and followed a poor monsoon in 2014. This was an exceptional occurrence as it was only the fourth time India has been hit by two successive monsoon rain deficits in the last 115 years. Monthly rainfall was 16% above average in June but 16% down in July, 22% down in August and 24% down in September.

Poor monsoon rains have badly hit India's agricultural production two years in a row. 2015/16 output dropped for most commodities, with the exception of wheat, following what was already a sizable contraction in 2014/15 (Figure 1). Fertilizer consumption during the wetter 2015 kharif season in India was excellent, according to IFA. However, disappointing sales during the subsequent rabi season led to an

inventory build-up in the distribution pipeline, resulting in a decrease in fertilizer consumption last year².

A bite out of palm oil production

After decades of continuous growth, Southeast Asian palm oil production declined for the first time in almost 20 years due to the negative effects of El Niño on the world's two largest producing countries, Indonesia and Malaysia. Excluding China, both countries collectively account for over half of Asian regional potash demand due to palm oil's high K requirements.

Mature oil palms are grown over an area of 4.8 million hectares in Malaysia. The latest figures from USDA suggest the country's palm oil production fell by 11% in 2015/16 to 17.7 million tonnes. El Niño-related drought stress during 2015 and early 2016 reduced Malaysian palm oil yields, reports USDA, with production running well below normal. Half of the country's total mature oil palm growing area experienced 4-5 consecutive months of drought and, as a result, Malaysia's average palm oil yield fell by 13% to 3.69 t/ha in 2015/16.

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What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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Fertilizer handling – a growing market

Moving from traditional fertilizer handling methods to the latest technology offers great operational gains and clear commercial advantages. The benefits of such as switchover can prove surprising, as **Bertil Andersson**, Siwertell's sales manager, explains.



Siwertell's ship unloader in Paradeep, India.

PHOTO: SIWERTELL

Handling dry fertilizers and fertilizer raw materials in bulk poses some challenges. The three key aspects to handling fertilizers successfully are minimizing cargo degradation, limiting environmental impacts and maintaining high safety standards. However, to provide the greatest commercial benefits, fertilizer handling technology also needs to provide the high capacity and efficient through-ship performance that operators expect.

Totally-enclosed systems with high performance screw-type unloaders are leading the way, as they have the advantage of being able to satisfy all of these demands. Many operators and sectors have adopted and embraced this new technology. Others have yet to make the change, preferring to stick with traditional unloading methods instead, often because of the industry's relative conservatism.

By 'new technology', I do not necessarily mean a new and innovative development. Instead, I am referring to a technology that a company or terminal has not used up until now, or considered adopting.

Siwertell, which introduced its screw-type unloaders to the dry bulk handling market over 40 years ago, believes that conservative attitudes are steadily changing – mainly because the benefits of new technology are becoming increasingly hard to ignore.

Protecting workers and the environment

Fertilizer and sulphur terminals want bulk handling technology to increase efficiency and raise safety standards. Providing a clean environment, usually to comply with increasingly stringent regulations, is another major priority.

Paradeep Phosphates Ltd (PPL), a leader in the fertilizer industry in the state of Orissa, India, believes that environmental protection is a mainstream function of any business enterprise. In its view, every effort should be made to balance industrial activity with nature conservation.

Faced with severe environmental problems at its jetty, PPL needed a new, clean ship unloader. This is not an unusual situation. Protecting the environment and workers means that traditional methods for discharging sulphur are becoming increasingly unacceptable. To solve its problems, and following careful market research, PPL chose a **ST 640-D** rail-mounted screw-type Siwertell ship unloader fitted with a 4S safe sulphur handling system.

The flammable and explosive nature of sulphur is only a serious issue for enclosed systems. To address this problem, Siwertell developed its 4S system. This mini-

mises the risk of fires and explosions – and detects them when they do occur. The system also extinguishes fires and safely contains blasts, while ensuring that fires do not spread downstream through the conveying and storage network.

In 2011, the **Indian Farmers Fertilizer Co-operative Limited (IFFCO)** faced similar environmental problems and also needed to increase its unloading capacity.

IFFCO concluded that the ideal solution to these issues was to replace its existing grab crane with a high-efficiency, fully-enclosed **ST 790-D** rail-mounted Siwertell ship unloader also equipped with 4S.

The new system has been in commercial use since July 2013, discharging vessels of up to 75,000 dwt. The unloader can handle sulphur at a rated capacity of 1,800 t/h and rock phosphate at between 1,600 to 2,100 t/h, depending on its material properties.

Environmental concerns were again cited as a principle reason when Indian fertilizer specialist, **Coromandel Fertilizers Ltd**, based in Visakhapatnam, approached Siwertell. The company faced two important issues. Its 30-year old grab unloader needed replacing, while environmental claims from a naval base opposite its terminal also needed addressing.

After studying the available systems, and visiting a number of reference installations,

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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ISSUE 475
 NOVEMBER-DECEMBER 2016

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Coromandel concluded that a continuous enclosed unloader was the answer to its requirements. It therefore ordered a Siwertell ST 490-F rail-mounted ship unloader with 4S. It now handles vessels up to 40,000 dwt at a rated unloading capacity of 400 t/h. The system has also satisfactorily resolved issues with the neighbouring naval base.

The importance of monitoring

In Australia, the Fremantle Port Authority selected a rail-mounted Siwertell unloader to discharge sulphur at its bulk cargo jetty in the outer harbour at Kwinana. The unloader has an enclosed conveying line with sealed transfer points. This feature, combined with its low noise emissions, ensures an environment-friendly operation for the port – a key aspect in securing the order.

The unloader at Kwinana is also equipped with a SiMon monitoring system. This provides instant performance feedback, has an automatic log book function, keeps track of maintenance intervals, and reduces time spent troubleshooting. A fibre optic cable included in its high-voltage power supply also allows the unloader to communicate with the port authority's main office. In addition, the SiMon system provides our engineers in Sweden with remote online access, enabling them to follow, supervise and, in principle, also operate the machine from the other side of the world.

Weighing 528 tonnes, the Fremantle Port Authority's unloader handles ships up to Panamax size and has a rated unloading capacity for sulphur of 1,300 t/h.

Demonstrating the benefits

Despite Siwertell's large portfolio of world-wide installations, some operators still need to be convinced about the benefits of switching to more efficient technology. Some believe that our technologically-advanced solutions will not have the reliability of more basic machinery such as grab cranes. However, this view does not stand up to scrutiny, as we are able to provide numerous customer references. These demonstrate the soundness of our designs, the quality of our engineering and the high standards of our service. This combination of qualities results in excellent reliability and very satisfied terminal operators. Our references also show that our installations conserve energy and protect the environment, two important benefits that are becoming increasingly valued globally.

Integrated, uncompromising and economic

With the exception of the standardised conveyor system, Siwertell unloaders are typically tailor-made to suit the individual requirements of operators. Our unloaders have a small physical footprint and are lightweight when considered alongside other technologies with comparable through-ship rates. This lowers the investment needed in jetty construction, adding to their overall competitiveness. With effective maintenance, timely replacement of worn parts and periodic upgrades, our systems can be expected to give excellent performance over many decades.

In addition to delivering stand-alone systems, Siwertell can provide fully-compatible downstream and upstream conveying solutions, configured and matched to the unloader or loader. We also offers design, construction and installation services.



Ship unloader, Gresik, Indonesia.

PHOTO: SIWERTELL

These are valued by customers planning complex import/export terminals with high capacity loaders, unloaders, conveying systems and flexible storage arrangements.

In many areas of the world minimising spillage and emissions to the atmosphere is no longer an optional extra. Environmental controls mean many terminal owners need to take steps to ensure their cargo handling operations are clean.

People are often reluctant to take action because they think the new solution will involve compromise, so causing damage to their company's competitive advantage and its bottom line. But the complete opposite is actually the case when it comes to clean dry-bulk handling. The truth is that investing in a Siwertell unloader for environmental reasons also boosts operational efficiency and profitability.

Our market-leading totally-enclosed unloading and conveying systems minimise dust emissions and eliminate spillage. This means there is no wastage and the operator receives all of the shipped cargo. Clean-up costs are also minimal or non-existent as the ship, terminal and surrounding areas remain unpolluted. The working conditions for crew and port personnel are greatly improved too.

Real-world unloading capacity

The rated discharge capacities of Siwertell unloaders are impressive, but they do not tell the whole story. Our real strength lies in 'through-ship' capacity. This indicates how long it actually takes to unload a ship, something which is naturally far more important than the peak rate achieved.

A grab crane starts off at a great rate when attacking a full cargo hold. But as the level of cargo in the hold falls, the grab has to travel further and further and so its discharge rate decreases, significantly and progressively. In addition, grab performance drops-off even more when the cargo level falls to the point where the grab cannot fill itself completely. Furthermore, grab cranes require the operator to invest in a downstream conveying system able to handle the peak rates briefly achieved when the cargo hold is full, even though these conveyors will be operating at well below their design capacity for most of the time.

These limitations do not apply to our screw-type unloaders as unloading is continuous. The rate remains virtually constant right down to the tank tops. The pick-up of cargo from beneath the surface, layer-by-layer, also means disturbance and dust creation are kept to a minimum. Because of this, the final clean up requirements for screw-type unloaders are far less than for traditional unloading systems. The constant rate of discharge ensures that downstream conveying systems perform optimally, in contrast to the peaks and troughs in throughput experienced with grab unloaders.

Moving with the times

We are pleased to say that Siwertell unloaders and loaders are making good inroads into the worldwide trade in bulk fertilizers. We are working hard to ensure that operators understand the reasons for this success, especially when it comes to replacing old equipment, making plans for a new terminal or expanding an existing port.

phosphates & potash

INSIGHT

49 SOP: the second largest potash market

54 Phosphate and potash mining innovation



CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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SOP: the second largest potash market



Sulphate of potash (SOP) fertilizer commands a premium price due to its value as a chloride-free source of potash for lucrative cash crops such as tobacco, tree nuts and citrus fruits. We examine the global demand for SOP and the prospects for new primary and secondary supply over the medium-term.

The potassium sulphate (SOP) fertilizer market has come under the spotlight recently. Primary SOP projects in particular have attracted the interest of investors in recent months.

The explanations for this, and the overall attraction of the SOP market, are not hard to fathom. As a potash fertilizer, SOP is second only to potassium chloride (MOP, muriate of potash) in terms of global market size, accounting for about 8% of world potash demand. SOP prices have also appreciated by around 10% in the last three years whilst MOP prices have declined by more than two-fifths over this period. These changes mean that SOP is currently enjoying a price advantage of almost \$300/t over MOP.

SOP also has a number of distinct agro-nomic advantages. It is chloride-free and

combines a high potassium content (50-52% K₂O) with sulphur, a beneficial secondary nutrient. This makes SOP a particularly valuable fertilizer for those crops with a high demand for potash and a low tolerance for chloride. Notable examples include tobacco – whose combustibility is hampered by chloride – and almonds which are chloride-intolerant yet still require potash in large amounts.

Premium price sparks interest

One of the most striking aspects of potash pricing since 2013 has been the divergent trend in SOP and MOP product prices – and the sharp rise in the SOP price premium (Figure 1). In Europe, SOP prices have held up and been “incredibly resilient” over this period, while MOP prices plunged, partly as a result of greater competition between

Russian producers, suggests Sean Mulholland, senior consultant at CRU Consulting¹.

“As a result the premium for SOP soared from an average of about 80% previously to over 140% in 2014,” explains Mulholland. “The margin is still really very bright – I think this goes some way to explaining the interest in SOP projects we’ve witnessed.”

The SOP price premium has remained high during 2016. As of early September, Baltic Sea MOP was trading at around \$208/t versus \$499/t (€460/t) for NW Europe SOP.

Demand for low-chloride potash grows

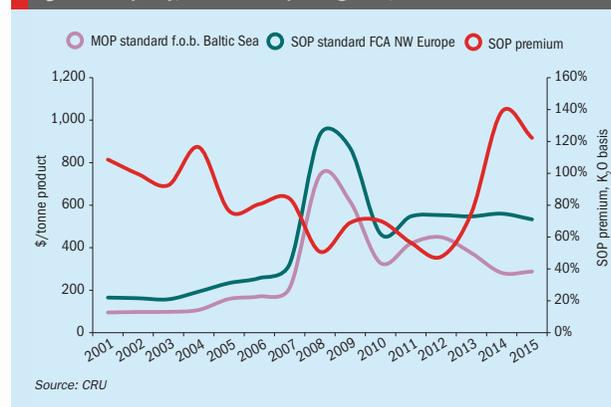
The demand for SOP, and its price premium, are attributable to a number of factors. But the ability of SOP to provide the potassium needed by crops in chloride-free form is undoubtedly a key market driver.

“Although the potassium requirement of crops is the most fundamental determinant, it’s really the cultivation of chloride-intolerant and chloride-sensitive crops which is the core driver of MOP demand,” suggests Mulholland. “MOP, the cheapest form of potash, contains high levels of chloride which can be harmful to the yield and quality of many crops.”

Crops have different tolerances to chloride and show a spectrum of yield and quality responses to its presence (*Fertilizer International*, 471 p39). Whilst chloride-free sources of potash such as SOP may be the only choice for chloride-intolerant crops, they are optional for crops with less chloride-sensitivity – and will only be applied if yield and quality improvements justify the extra cost involved. Because of this, the market requirement for SOP can be split between ‘inelastic’ demand from chloride-intolerant crops and ‘elastic’ demand from other less chloride-sensitive crop types.

“Tobacco and almonds are particularly intolerant towards chloride and SOP demand for these two crops is particularly inelastic,

Fig 1: SOP capacity, demand and operating rates, 2007-2015



Source: CRU

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
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as applying MOP would be highly detrimental to crop yield and quality," explains Mulholland. "However, there's quite a wide range of other crops for which SOP demand is more elastic – and responds to both the SOP premium and the willingness to pay that premium."

CRU have analysed SOP pricing based on the value of four individual components: its potassium value, low-chloride value, sulphur value and a component adjustment factor (Figure 2). Their analysis suggests that it is the 'low-chloride value' of SOP which has supported market prices in recent years, at a time when its 'potassium value' has declined.

The sulphur component of SOP also provides some value, although according to CRU this is relatively low due to the availability of other cheaper forms of nutrient sulphur. The final component of SOP value, 'combination adjustment', reflects the cost benefit of combining sulphur and potassium together in a single fertilizer application.

China transforms market demand

China has been responsible for a 2.1 million tonne expansion in global SOP demand in the last seven years (Figure 3). "China's really been the undisputed engine of world SOP demand growth," says Mulholland. "It's almost single-handedly increased the size of the global market by about 50% since 2007 – taking global demand from about four million tonnes to over six million tonnes today."

China also looks set to lead the way on global demand over the next four to five years, with the country's SOP consump-

tion expected to increase by a further 1.1 million tonnes by 2020, helping global demand to grow from 6.1 million tonnes currently to 7.5 million tonnes by the end of this period.

China should account for about 55% of global SOP consumption this year. Domestic demand has increased in recent years in response to a rapid rise in the cultivation of chloride-sensitive crops such as fruit, vegetables, tea and tree nuts.

Around 65% of China's 3.9 million t/a SOP consumption is concentrated in southern provinces where the majority of the country's fruit and vegetables are grown. Growth in demand has coincided with a significant expansion in China's SOP capacity, although production is largely located in western provinces resulting in a geographical mismatch with demand.

Outside of China, global growth in SOP demand has been virtually nil since 2007, although demand ex-China is expected to pick up and increase steadily at 1.9% annually over the next four years. SOP consumption in Europe and Africa is likely to account for about 70% of this future demand growth.

Although their growth prospects are modest, North America and Europe represent sizable markets for SOP. "North America and Europe account for around 60% of SOP demand outside China", confirms CRU's Sean Mulholland. "These are two markets in which crop quality can generate premiums for growers who can then justify additional expenditure on SOP."

The gulf between Chinese SOP consumption (3.9 million t/a) and the rest of the world is illustrated by the massive

demand gap with the United States. The US, although the second largest SOP market globally, consumes just 405,000 t/a, about 10% of Chinese demand.

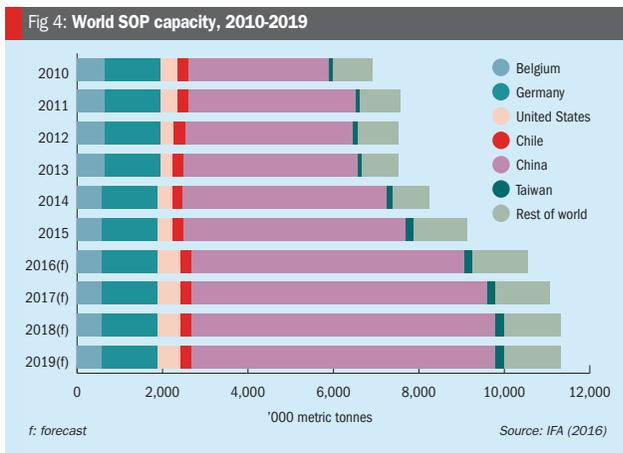
The US remains a sophisticated, mature market for SOP, though, even if its demand outlook is flat compared to China. The concentration of SOP demand in California (35%) and Florida (12%) is also a notable feature of the US market.

Demand in California is driven by tree nuts. The state is the world's single-largest producer of almonds, an extremely chloride-sensitive crop with a high demand for potash. California's demand for SOP from tree nuts such as pistachio, walnuts and almonds has more than doubled over the last two decades, from 62,000 tonnes in 1990 to 125,300 tonnes in 2013. The requirement from pistachios has been strongest – rising at 8.0% annually – although almond growing remains responsible for over 95% of tree nut SOP consumption in the state.

Supply and trade dynamics

The outlook for world SOP supply was outlined in a new report from the International Fertilizer Association (IFA) published in January². This revealed that around 44% of the world's 9.1 million tonnes of SOP capacity comes from primary production from natural brines using solar evaporation. The other 56% of capacity involves secondary production, usually by combining MOP with sulphuric acid using the Mannheim process.

Supply is very concentrated with more than three-quarters of the world's SOP capacity being located in just three countries, China



(57%), Germany (14%) and Belgium (6%). Other minor but significant producers include the US (4%), Chile (3%) and Taiwan (2%).

Looking ahead, IFA expects world capacity to increase from 9.1 million tonnes to 11.3 million tonnes by 2019, a rise of almost a quarter (Figure 4). Almost 90% of this extra capacity (1.9 million tonnes) will originate in China. Extra secondary capacity is likely to lead the way, increasing by 1.6 million tonnes globally, whereas primary capacity is forecast to increase by around 0.6 million tonnes².

The primary versus secondary production split creates "some very interesting dynamics in the SOP market", says CRU's Sean Mulholland:

"Primary producers tend to be very large-scale and low cost. Whereas secondary producers are significantly exposed to fluctuations in price for both input MOP and output SOP. They pay particular attention to the premium between the two as this significantly impacts their margins. Many secondary producers are doing well in the current market as premiums are quite high."

Primary supply transforms China

The entry of Xinjiang-based primary SOP producer Luobupo transformed the Chinese market six years ago. China depended almost entirely on secondary SOP production prior to this. Luobupo's release of an extra one million tonnes of low-cost primary SOP into the market from 2009 onwards inevitably led to a sharp reduction in prices.

"The response from Chinese demand was not big enough to prevent a fall in prices and an associated rapid contraction in the SOP price premium over MOP," explains Mulholland. "This really squeezed secondary producers in China and forced their operating rates to almost half overnight."

China moved from less than two million tonnes of SOP capacity in 2007 to in excess of five million tonnes currently. However, rapid demand growth in the Chinese SOP market has been strong enough to absorb newly-commissioned primary and secondary capacity, enabling prices and operating rates to recover since the turn of the decade (Figure 5).

China's primary SOP capacity is located inland, being concentrated in the far western provinces of Xinjiang (1,425,000 tonnes) and Qinghai (1,230,000 tonnes), whereas the coastal provinces of Guangdong and Shandong dominate secondary production. A location near to ports is also a matter of necessity for secondary producers as they rely on imports for their main raw material, MOP.

IFA and CRU both agree that there will be no let-up in Chinese capacity additions over the next five years. CRU is forecasting that China will add a further 2.45 million tonnes of SOP capacity by 2020, for example.

"It's in Qinghai where most of the additional 1.35 million tonnes of primary SOP supply will be produced," predicts Mulholland. "This is in addition to the planned 0.9

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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Fig 2: Four value components of SOP

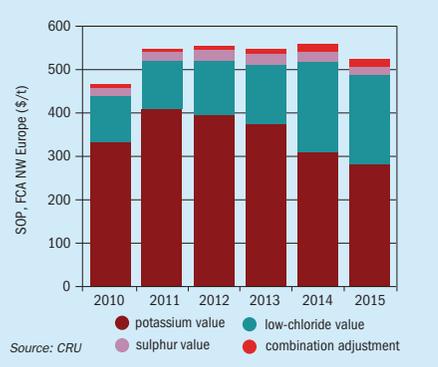


Fig 3: World SOP demand, 2007-2020

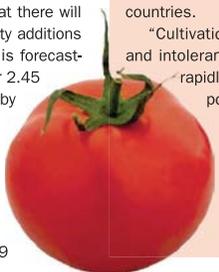
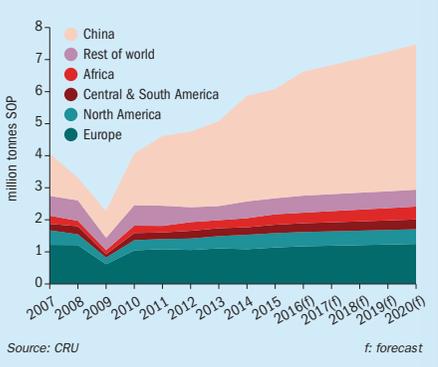
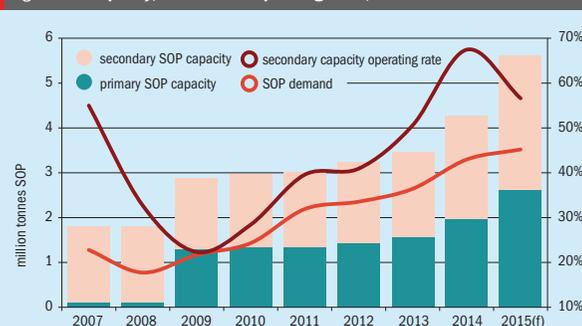


Fig 5: SOP capacity, demand and operating rates, 2007-2015



Source: CRU

million tonnes of secondary production capacity encouraged by the relatively high SOP price premium."

Primary supply prospects

According to CRU, an increase in primary supply outside China has the potential to transform the SOP market. It has identified a total of 15 primary SOP projects globally. Six of these are classed as probable, another six as possible and the remaining three as speculative.

"They're not yet in our base case forecast because, by and large, they haven't achieved financing," admits Mulholland. "East Africa is particularly interesting as there are four large SOP projects planned in Eritrea and Ethiopia. There are also other projects, largely speculative, in South Asia and Australia."

How many of these projects will eventually enter production, given the absence of financing, remains an open question. Whether likely or not, increasing primary SOP supply outside of China is an important market issue to watch. This is because it could herald a decline in prices, ratcheting-up cost pressures on secondary producers in particular.

Europe dominates exports

World trade in SOP largely comes from just five countries, namely Germany, (830,000 tonnes), Belgium (415,000 tonnes), Taiwan, (135,000 tonnes), Chile, (130,000 tonnes) and Canada (46,000 tonnes). Imports, in contrast, tend to be highly dispersed. Annual import deliveries of tens of

thousands of tonnes are typical of most markets around the world.

Germany and Belgium both export SOP worldwide and together account for over 80% of global exports. Chile primarily supplies SOP to the Americas, sending only minor volumes to Europe and Africa, whilst Taiwanese exports targets smaller markets in East Asia.

A sudden jump in Chinese exports to over 60,000 tonnes last year prompted questions about whether China was about to emerge as a major SOP exporter, especially given its large-scale capacity additions. The prospect of this happening is likely to recede, however, due to higher Chinese SOP production costs over the medium-term.

Preferential freight tariffs are set to disappear, making it increasingly expensive for inland Chinese primary producers to transport SOP to the coast for export. Falling East Asian SOP prices may also help make Chinese exports uneconomic by 2020, according to CRU. Nevertheless, China will still have an ability to export SOP opportunistically, should market conditions allow.

Prices signals and extra capacity

The large gap between the current price of SOP and production costs suggests there is a need for extra capacity in CRU's view. The difference between the average SOP price last year (\$533/t) and the industry's highest production cost (c. \$420/t) is a clear market signal, according to Sean Mulholland: "If we compare the cost curve with prices which prevailed in 2015, we can see that prices really are signalling to the market that additional capacity is required."

Chinese primary production is the most competitive globally, with SOP producers in Xinjiang and Qinghai occupying the lowest position on the cost curve, despite the cost of getting their product to port. Secondary producers around the world, in contrast, generally occupy the upper part of the cost curve.

The purchase of MOP is the single biggest cost factor for secondary producers. Their costs are also linked to the market for hydrochloric acid, an unavoidable by-product of the Mannheim process. This is highly localised and can vary from region to region. Secondary producers can even be forced to curtail SOP production if they are unable to place hydrochloric acid, a very real problem in Europe and China, according to CRU.

Medium-term price resilience

SOP prices are forecast to remain above \$500/t over the medium-term, despite continuing MOP price weakness. The current SOP price premium is therefore likely to remain in place between now and 2020, according to CRU's price outlook. This should mean that secondary SOP producers will continue to operate profitably, as long as hydrochloric acid by-products are managed well.

On the demand side, future rises in Indian SOP consumption remain conditional on the government overhauling the Nutrient Based Subsidy (NBS) scheme to allow SOP to compete with MOP on a level playing field.

The Iranian market looks more promising, being described as "one to watch" by CRU. The abolition of sanctions earlier this year could boost SOP demand if Iran exports more pistachios and other chloride-sensitive crops.

The greatest demand potential for SOP probably lies in Central and South America. However, achieving demand growth in these markets requires intensive marketing efforts, and is therefore unlikely to happen overnight. ■

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino
Americano,
Buenos Aires

COVER FEATURE 2

Argentina's
fertilizer market

COVER FEATURE 3

Drip irrigation
review

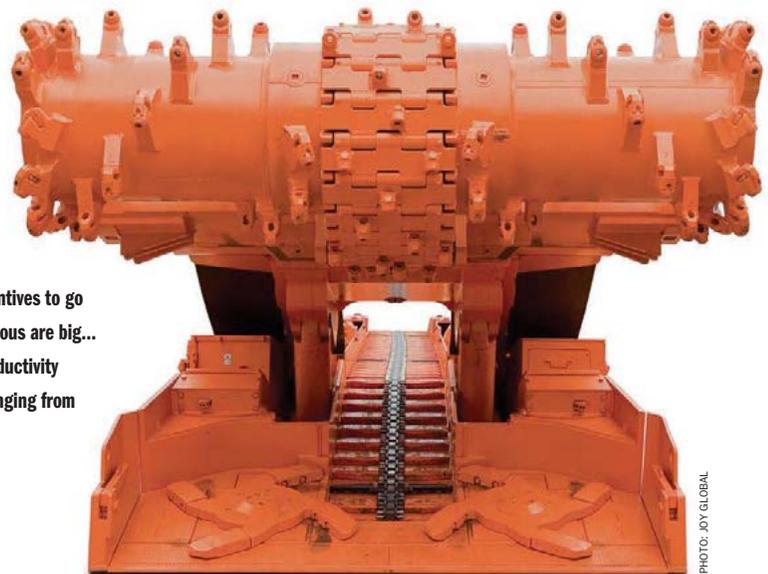
COVER FEATURE 4

P&K mining
innovation

FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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“The incentives to go autonomous are big... with productivity gains ranging from 20-60%”

PHOTO: JOY GLOBAL

Phosphate and potash mining innovation

We look at state-of-the-art technology used in phosphate and potash mining, including continuous mining and haulage systems, in-pit crushing and conveying, and paste plants for tailings thickening.

Modern economies are built on the secure supply of affordable materials. The reason why the price of many mineral commodities has remained largely unchanged over successive decades – even though demand has risen and extracting ore has become ever harder – can be credited to one crucial factor: innovation. Phosphate and potash producers, like others in the mining sector, look to innovation to control their costs and maintain margins over the longer term.

Learning from others

Combined phosphate rock and potash extraction approached 300 million tonnes last year. Mining on this scale is, however, relatively modest in global terms, representing just 3% of the volume of coal and iron ore mined worldwide every year.

The disparity in the size of P & K extraction relative to the mining of other commodities is mirrored by the scale of capital

investment. Large mining companies therefore have a strong incentive to innovate as a way of cutting their vast capital costs. Any advances in iron and coal extraction, and wider mining technology trends, are therefore closely watched by phosphate and potash miners with a view to adopting these subsequently.

Automation, an inexorable trend

The three main components of mining are drilling, truck haulage and long-distance railway systems. The control and automation of drills, trucks and trains using remote operation centres is set to transform the economics of large-scale ore movement. Indeed, these type of autonomous mining operations are “the number one mining innovation set to turn the industry upside down”, according to the Saskatchewan Mining Association.

Two major iron ore producers, Rio Tinto and BHP-Billiton, have already gone down

Joy Global's new 12HM46 heavy-duty continuous miner is specifically designed for mining salt, potash, gypsum and trona.

High-density tailings disposal

A holistic approach

In August 2015, Outotec, a global leader in mineral processing technology, agreed a €40 million EPC contract with Yara to design and deliver a paste plant for treating tailings at the Siilinjärvi phosphate mine in Eastern Finland. The agreement covered engineering, equipment supply, construction and commissioning of the paste plant, as well as spare parts and services. The new plant is expected to become operational in the spring of 2017.

Outotec's proprietary high-density tailings disposal system dewaterers and thicken tailings slurries. This treatment process, by increasing the percentage of solids present, makes it possible to store tailings slurries as a paste. Treating slurries to make them more dense and compact is desirable as it extends the lifetime of tailings storage facilities. Paste plants also operate more efficiently by returning any water reclaimed from the dewatering of tailings to the process water circuit.

Partnership

“Yara is our long-term partner with whom we have developed and pilot tested an optimal thickened tailings solution based on Outotec's paste thickener technology,” notes Kalle Härkki, Outotec's head of minerals processing. “Extended the lifetime of the existing tailings facilities and efficient water circulation are noteworthy from an environmental point of view.”

The production of around one million tonnes of phosphate concentrate at Yara's Siilinjärvi mine, the only mine of its type in Western Europe, creates approximately 10 million tonnes of tailings per year. The tailings, a mixture of sand and water, are currently disposed of conventionally.

Teija Kankaanpää, Yara's head of mining operations at Siilinjärvi since 2010, has been heavily involved in the company's quest for a new approach to tailings treatment and storage. After several pilot tests, Yara became increasingly interested in using a paste plant to thicken tailings as a solution. Beach



angle – the slope a tailings deposit makes after discharge – was a major consideration.

“We wanted to get some sort of a guarantee for the estimated beach angle that could be made from our tailings, but no one would give us such a guarantee at that time,” said Kankaanpää.

One of the obvious benefits of increasing your beach angle, explains Kankaanpää, is that you can deposit more tailings using the same footprint. With a paste plant, there is also less water than in a conventional tailings pond, reducing the potential risk of dam failure. Yara's next step was to buy a pilot paste plant able to handle 10% of Siilinjärvi's tailings streams.

Going full-scale

“We bought the pilot plant from Outotec, and we ran it for about 18 months,” explains Kankaanpää. “After doing several tests, we determined that we would need a full-scale paste plant to reach the targets we wished to achieve.”

The experience gained from the pilot plant was invaluable when it came to the design of a full-scale plant to treat all of Siilinjärvi's mine tailings.

“We had two candidates in the last phase, but the technical feasibility and economics proved to the advantage of Outotec,” comments Kankaanpää. “We have had some tough discussions, but we have been able to solve them together, and I think the spirit has been that, if there is a problem, we solve it and move forward in a constructive way.”

Kankaanpää concludes: “Safety comes first in all that we do in Yara, and Outotec has shown good safety performance and high commitment to our safety procedures”.



Interior (this pic) and exterior (above) of Outotec's paste plant.

PHOTOS: OUTOTEC

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

FERTILIZER INTERNATIONAL
ISSUE 475
NOVEMBER-DECEMBER 2016

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In-pit crushing & conveying

In June 2015, thyssenkrupp Industrial Solutions secured a contract to develop and construct an in-pit crushing & conveying (IPCC) system for the Koashvinsky phosphate mine operated by OJSC Apatit, a subsidiary of Russian fertilizer producer PhosAgro. The mine is located near the city of Kirovsk on the Kola Peninsula in northern Russia.

The IPCC system will be the first of its kind in a Russian open-pit mine. The system's hoppers have sufficient design capacity to accept trucks with a payload of up to 220 tonnes. The direct-feed crushing plant is also equipped with a gyratory crusher designed to accept 6,200 tonnes of material per hour.

The new high-capacity semi-mobile crushing plant will replace the truck haulage of waste materials outside of the mine. Instead, these materials will be crushed to a conveyable size and transported by curved conveyor over a distance of around four kilometres to an external waste site. At the end destination, a crawler-mounted spreader with an hourly capacity of 6,200 tonnes will then discharge material from the conveyor. The IPCC system will substantially cut operating and maintenance costs and CO₂ emissions. It will also provide a higher level of operational safety.

Design and planning

thyssenkrupp began the project in 2014 with the full involvement of Apatit engineers. The design, construction and choice of crushing equipment were selected according to the following material characteristics: compressive strength, tensile strength, cleavage, fracture behaviour and adhesiveness/humidity.

The IPCC system designed for Apatit's Koashvinsky mine is a combined crushing unit able to handle both hard waste and moraine material, and has the capacity to handle up to 30 million tonnes of waste a year. The system needed to be able to accept materials with compressive strengths averaging 50-190 MPa up to a maximum of 320 MPa. The size and design of equipment was based on the following material properties:

- Specific in-situ density: 2.8 t/m³
- Swell factor on belts: 40%
- Specific loose weight: 2.0 t/m³
- Maximum moisture content: 3% run of mine

As part of the project, thyssenkrupp arranged visits to a number of European reference sites where other long-distance curved conveyors and crawler-mounted spreaders are currently installed and operating.

Location

Semi-mobile IPCC systems need to be located deep inside open-pit mines as near as possible to the material being mined. Their mobility allows the systems to be relocated using transport crawlers as mining progresses.

For the Koashvinsky mine, it was decided to locate the direct-feed crushing plant not inside but close to the existing mining operation. The transport conveyor needed to be routed across road and rail crossings and fit the local



Direct-feed semi-mobile crushing plant at Norsk Stein, Norway.

PHOTO: THYSSENKRUPP

topography. At least one curved conveyor section was necessary to ensure the most economical and environmentally-acceptable route.

The benefits

With an IPCC system, truck haulage is only used to move material inside the open mine pit. The use of trucks is greatly reduced and restricted to shuttling material, horizontally or downwards, to the semi-mobile crushing plant. In terms of operational expenditure (Opex), IPCC has the following advantages versus a conventional system using diesel trucks:

- It is electrically driven with a higher efficiency than diesel motors
- Has a lifetime of up to 40-50 years with regular maintenance
- Significantly reduces operating personnel due to partial automation
- Increases mine safety
- Increases utilisation
- Reduces CO₂ emissions, the amount depending on the origin of the electricity used

Although the investment costs are always higher for a mobile or semi-mobile IPCC system, the reduced Opex typically leads to a return on investment within 2-4 years of successful commissioning and operation.

"The switch to the new semi-mobile system is expected to lead to a significant decrease in truck haulage in the Kirovsk mine," comments Thomas Jabs, head of mining systems at thyssenkrupp's resource technologies business unit. "Thus, our customer will profit not only from a substantial reduction in operating and maintenance costs, as well as lower CO₂ emissions, but also from a higher level of safety during operation."

Co-operation

The IPCC project with Apatit is being delivered through a joint German-Russian team. Two of thyssenkrupp's mining technology subsidiaries in Germany – Mining Systems and Processing – are collaborating with local partner thyssenkrupp Russia. The IPCC system at Koashvinsky mine is scheduled to be erected and commissioned in 2018. Local Russian companies are also deeply involved with the project and are working closely with thyssenkrupp.

Dr Sven Müller-Rinke, managing director of thyssenkrupp Russia, said: "This will be the first in-pit crushing reference based on our technology in Russia and a good example of how our customers benefit from the worldwide integration of our plant technology business." ■

this path and set up remote operations centres in Perth, Western Australia. These centres, by precisely controlling ore grade and tracking ore movements, are more like manufacturing operations than a conventional mine. The centres are able to route materials, bucket-by-bucket, to suitable processing streams, using detailed information on grade and impurities gained from on-line analysis.

PotashCorp pioneered potash mining automation at its Rocanville mine in Saskatchewan over two decades ago. A mine-wide automation and control system supplied by Allen-Bradley was installed in 1994. This uses 29 industrial computers linked-up to 3,100 points throughout the mine, has over 600 control functions and can generate 3,350 alarms. This system, by enhancing ore extraction and recovery, has provided a successful example of automation which other potash producers have followed subsequently.

Automation is a continuing pervasive industry trend. Rio Tinto is already commissioning the mining industry's first automated, long distance, heavy haulage rail network, for example. Commentators also believe that autonomous mining has now reached the stage where it is fully commercially viable.

"Autonomous mining equipment is available here and now, and the incentives to go autonomous are big," a report from banking group Citi concluded last year. "Our calculations suggest at least \$1.4 billion of savings are feasible, with productivity gains ranging from 20-60%."

Although iron ore and coal mining act as innovation pathfinders, there are plenty of examples of quick uptake of new technologies by phosphate and potash miners. The use of paste plants to thicken tailings, so making their storage more safe and efficient, is one such innovation. The drive for operational efficiency has also spurred innovations such as in-pit crushing and conveying. Larger and more innovative continuous mining and ore haulage systems are also entering the market.

A selection of the latest and most promising phosphate and potash mining innovations are outlined here, together with their key advantages.

Continuous miners

Continuous miners have a long history. They were first popularised by the underground coal industry in the 1960s and have since become a mainstay of potash, gypsum and salt mining. Agrium's

Vanscoy mine in Saskatchewan extracts potash using four CM345N continuous miners supplied by Caterpillar. A fleet of five automated Sandvik (formerly Marietta) continuous miners are also in operation at PotashCorp's Rocanville mine.

PotashCorp subsequently ordered a fleet of Sandvik MF420 borer miners for its Picadilly mine in 2010. These massive borers were the world's largest self-propelled mobile underground mining machines at the time of their development. As well as the MF-series, Sandvik currently markets the more compact and manoeuvrable MC-series of continuous miners.

Joy Global, the US mine machinery manufacturer, has sold over 6,000 continuous miners globally. The firm also shook-up the industry in the late 1980s by introducing the first single-operator continuous haulage system, the Joy Flexible Conveyor Train (FCT). This optimised production by offering true continuous mining and haulage without the delays typical of batch loading. Joy Global had also pioneered previous innovations such as radio remote control and AC traction drive systems in continuous miners.

Potash miners have placed over 70 orders for continuous miners, FCT systems and other equipment from Joy Global. The firm's continuous miners are used by US producer Intrepid Potash at its New Mexico mine in the US and by ICL at its Boulby mine in the UK.

The productivity of continuous miners has more than tripled in the last decade, according to Joy Global. Increases in their size, weight and power means they can now operate at more economic production rates than traditional drill and blast methods.

Earlier this year, Joy Global released its new 12HM46 heavy-duty continuous miner, a model specifically designed for mining salt, potash, gypsum and trona. The new miner is a step forward from Joy's other 12HM models which are already successfully operating in other industrial mineral mines around the world.

"This machine achieves up to a 20% increase in production over the existing machines, depending on what haulage options and mine layouts are used, making this Joy's most productive drum miner ever," says Brian Ziegler, product manager at Joy Global. "It has upgrades to all the major frames, pivot points, pins and bushings to increase service life and reduce total cost of ownership."

This is impressive as the previous 12HM36 model was reportedly the most powerful drum type continuous miner avail-

able when it was first manufactured. The 12HM46 has greater cutting stability, due to its greater mass, and also employs an upgraded traction drive system.

"We've also introduced a new control system, with vastly increased processing power, allowing future upgrades in automation and control," says Ziegler. "The new system also allows Wi-Fi access to monitor and troubleshoot the machine without interrupting production."

The new machine has a production rate of up to 1,000 tonnes per hour. Outputs above 8,000 tonnes per day should now be achievable, according to Joy Global, by combining the 12HM46 with continuous haulage in a herringbone or multi-pass production system.

Continuous haulage

When it comes to continuous haulage, the 1,200 t/h capacity Flexiveyor designed and produced by Prairie Machine and Parts (PM&P) in Saskatoon has proven to be a popular choice in the potash industry. These can be used in combination with PM&P's continuous miners, the Xcel series rotary boring machines, or installed behind other types of mining machine.

The Flexiveyor employs a number of interconnected 20-foot-long cars. These form a fixed-length, train-like haulage system. Each Flexiveyor consists of a loading car, which accepts ore from the miner, and conveys this via a series of intermediate cars to a final car which discharges the ore onto a panel belt.

Some 20 Flexiveyor systems are installed in potash mines in Saskatchewan – Agrium's Vanscoy mine being one – and other locations worldwide, including the UK and New Mexico. A 300-foot long 15-car Flexiveyor configuration is typically used in Saskatchewan's potash mines. Haulage is controlled via an operator interface using an industrial computer.

Although it competes with the some of the world's biggest mining manufacturers, PM&P does have one major competitive advantage, according to its president Murray Popplewell: "PM&P is the only manufacturer in the world that manufactures a complete mining system. That's right from the mining machine, through to the belt drive. We have a complete mining system."

Potash and phosphate industry innovation is not just restricted to upstream mining. Process technology is also advancing apace. Fertilizer International will update its readers on the latest developments in downstream P&K production throughout 2017. ■

CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

P&K mining innovation

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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino Americano, Buenos Aires

COVER FEATURE 2

Argentina's fertilizer market

COVER FEATURE 3

Drip irrigation review

COVER FEATURE 4

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1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31



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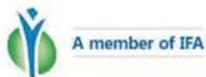
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CONTENTS

What's in issue 475

COVER FEATURE 1

Fertilizer Latino
Americano,
Buenos Aires

COVER FEATURE 2

Argentina's
fertilizer market

COVER FEATURE 3

Drip irrigation
review

COVER FEATURE 4

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innovation

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